Retrograde Ureteroscopy

HANDBOOK OF ENDOUROLOGY

Edited by

Petrişor Aurelian Geavlete

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Contributors

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Preface

This fourth book in the series *Handbook of Endourology: Retrograde Ureteroscopy* continues with the procedures designed for ureteral approach, being the first of two volumes dedicated to the upper urinary tract.

Within the pages of the handbook, the technological progress of the past decades becomes maybe even more evident. Miniaturization, development of lasers, special materials for flexible scopes, and image chips, etc., have allowed the continuous reshaping of this field.

This process is continuing, each year bringing new developments in the field, new endoscopes or instruments aiming to improve the efficacy and safety of the procedures, or the broadening of the indications. Today, the retrograde approach is seriously challenging the other minimally invasive options for upper urinary tract pathology treatment, percutaneous approach, and SWL.

This volume is based on a broad experience of more than 11,500 rigid and semirigid ureteroscopies and more than 2,500 procedures using flexible ureteroscopes performed in the last 25 years. All this experience has allowed us to apply retrograde ureteroscopy in almost all the situations that can be approached in this fashion, with all the challenges, particular situations and, why not, most of the complications that can be encountered. Today, all this experience, carefully recorded, can be passed on to the readers. As in the previous books, the theoretical notions are supported by more than 1500 images captured during personal interventions, in the previously mentioned situations.

At the beginning, retrograde approach of the upper urinary tract was performed only for diagnostic purposes or for treatment of stones. Now, selected cases of patients with other upper urinary tract conditions can be treated using these techniques.

The volume starts with the history of the procedures and the description of the various endoscopes (semirigid or flexible, conventional or digital), energy sources, ancillary instruments, and stents available for clinical use. It seems that the variety of these instruments developed for the upper urinary tract is even more diverse than those for the endourological approach of the lower urinary tract.

This volume continues with the description of diagnostic ureteroscopy and then presents, in detail, the therapeutic approach for upper urinary tract lithiasis; caliceal diverticulum; upper urinary tract tumors; ureteral, uretero-pelvic junction, and infundibular stenosis; iatrogenic lesions; and finally, the ureteroscopic approach in selected situations (pediatric cases, pregnant women, anomalous ureters, or kidneys).

The indications, technique, limitations, complications, and results are thoroughly described for each of these pathological entities.

Being one of the most experienced centers in the world in ureteroscopy, with a unanimous national and international recognition, we consider that this volume can guide the diagnostic and therapeutic conduct for any urologist, as well as for other specialists.

Ureteroscopy has presently become one of the most frequently used minimally invasive methods in urology. The impressive technology that is under constant evolution, as well as the experience of many renowned urology centers, recommend the publishing of this book.

Editor

Professor Petrişor Aurelian Geavlete, MD, PhD

Chapter 1

Chapter 2

2.1. Generalities

The upper urinary tract, composed of the pyelocaliceal system and the ureter, ensures the function of vector of the urine from the kidney to the urinary bladder through peristaltic contractions. Knowing the internal configuration of the upper urinary tract, as well as the topography and the relations of its composing segments, is essential for the proper integration of information provided by endoscopy and fluoroscopic monitoring. Also, adapting the ureteroscopic technique to the micro- and macroscopic anatomical particularities of this segment makes it possible to perform endoscopic interventions with maximum efficiency and safety.

2.2. Notions of upper urinary tract histology

The histological structure of the ureter, renal pelvis, and calyces has major implications in the ureteroscopic approach of the upper urinary tract. Lesions in these structures during endoscopic maneuvers are relatively frequent and require adequate knowledge of the histological particularities.

The ureteral wall consists of three layers:

- tunica adventitia
- tunica muscularis
- tunica mucosa

The adventitia, which is the outside layer, is made of elastic connective tissue.

The muscular layer consists of longitudinal and circular smooth muscle fibers. Its abundant vascularization could explain the important bleeding that occurs in case of ureteral perforations.

In the upper 2/3 of the ureter, there are two muscular layers: a superficial one (circular, thin) and a deep one (longitudinal, thick). In the inferior 1/3, a third, external muscular layer with longitudinal fibers is added. These layers are interconnected by muscle fibers exchanged between the adjacent layers. Due to this extensive interconnection, the individual muscle layers do not have a strictly spiral arrangement around the ureter (Gosling, 1970). The density of the muscle fibers in the proximal ureter is reduced. Consequently, the proximal ureteral wall is thinner than the distal one, implying an increased risk of ureteral perforation.

The muscle layer of the uretero-vesical junction consists mainly of longitudinal fibers. The lateral fibers of the external longitudinal layer head toward the ureteral orifice, while the medial ones are intertwined with those from the opposite side, forming the interureteral bar. In this way, the bladder trigone is delimited. The circular layer disappears and its fibers arrange themselves in the form of islands and mix with the fibers of the internal longitudinal layer, forming helicoidal systems. This disposition of the muscular fibers at the level of the uretero-vesical junction plays a very important role in the antireflux mechanism. There are significant structural differences between the structure of the ureteral muscular layer and the vesical one (Gilpin and Gosling, 1983).

The smooth musculature of the ureteral wall plays a major role in the transport of urine. Through peristaltic contractions, the urine is propelled in the form of successive, rhythmical jets with a frequency of 1–4 per minute.

The ureteral mucosa is disposed in longitudinal folds that, on the transversal section, give the ureteral lumen its characteristic stellate aspect. It consists of a pseudostratified epithelium (polymorphic type covering epithelium, urothelium, or transitional epithelium) located on a dense corium, consisting of fibro-elastic connective tissue arranged irregularly. The epithelium is separated from the corium by a basement membrane.

The transitional epithelium represents a particular form of stratified epithelium whose cells present a high degree of plasticity. It has the ability to display its cells on several layers according to the extent of the surface that it must cover at a given moment. Classically, the urothelium has three cellular layers: basal, intermediate, and superficial.

In fact, all the cells of this epithelium reach the basal membrane, while the free surface is reached only by a part of the cells, which have a bulging and vesicular apical pole. The luminal cells of the urothelium are characterized by the presence of a specialized apical membrane, being attached to the ones situated toward the ureteral lumen through a junctional complex. Pluristratified nuclei are observed in hematoxylin-eosin staining. The first layer of cubic-prismatic cells from the basal membrane belongs to the basal or germinating layer. The cells have a polymorphic aspect (polyhedral or fusiform, piriform or “tennis racket” cells), with a poorly represented intercellular junction that allows them to slide. This layer of cells becomes unapparent after the epithelium’s distension.

A layer consisting of flattened cells can be observed on the surface. Each of them may cover one or several cells of the underlying layer (umbrella cells). They contain one to two round nuclei, while the cytoplasm presents, at the level of the free surface under the apical plasma membrane, a condensation (the cuticle) that has the role of sealing the mucosa.

One of the most important features of the urothelium is the increased size of the intercellular compartment.

In the normal upper urinary tract, there are no histological differences between the uretero-pelvic junction and the rest of the upper urinary tract. In case of obstruction, there is an increase in the amount of collagen around the muscle fibers and in the proportion of longitudinal muscle fibers, but with an overall decrease in the amount of muscle tissue.

The pyelocaliceal system has a similar histological structure with the ureter.

The mucosal layer is well defined and thick. The muscularis is relatively thin, composed of oblique fibers separated by connective tissue, without presenting the distinct layers from the ureteral level. In the small calyces, deep longitudinal muscle fibers are described that are inserted at the base of the papillae. Circular muscle fibers, whose contraction has a role in the expulsion of urine from the papillary ducts, also exist at this level.

All calyces and a part of the renal pelvis are surrounded by the renal parenchyma and the renal sinus fat. The adventitia from the distal part of the renal pelvis is continued by the renal capsule.

2.3. Descriptive anatomy of the upper urinary tract

2.3.1. The Pyelocaliceal System

The pyelocaliceal system consists of the renal pelvis and calyces. The urine from the collecting ducts (which cross the renal pyramids to open into the papillae) is collected in the small calyces (minor or secondary). At the renal level, there are 8–18 pyramids, but only 7–13 minor calyces, some of the latter having more than one papilla. These calyces converge to form the major calyces, which in turn open into the renal pelvis through the caliceal infundibula. The renal pelvis continues on to the ureter via the uretero-pelvic junction, which is situated at the level of the L1 vertebra.

According to the architecture of the pyelocaliceal system, Sampaio proposed the following classification (Sampaio, 2007):

1. Group A – the pyelocaliceal system has two main caliceal groups (upper and lower), the mediorenal area being dependent on one of these.
   a. Subgroup A1 – the mediorenal area is drained by secondary calyces, which are dependent on the upper or lower caliceal groups or even on both simultaneously.
   b. Subgroup A2 – the mediorenal area is drained by crossed calyces, some toward the upper caliceal group and others toward the lower one, with a space being delimited between them and the renal pelvis, called the inter-pyelocaliceal space.
2. Group B – the mediorenal area is drained independent of the upper and lower caliceal groups.
   a. Subgroup B1 – the mediorenal area is drained by a major caliceal group independent of the upper or lower calyx.
   b. Subgroup B2 – the mediorenal area is drained by 1–4 secondary calyces that open directly into the renal pelvis.

Another classification, proposed by Graves, describes four types of pyelocaliceal systems; two primary and two secondary. Thus, for type A, the upper and lower caliceal infundibula are arranged in the shape of the letter "Y," merging into an elongated renal pelvis. In type B, the lower calyx continues to the upper one, both merging with the renal pelvis at a 90° angle in the shape of the letter "T." Type C presents a "balloon"-type renal pelvis, the calyces being short and thick. Type D presents a small, round renal pelvis and prominent calyces with long infundibula. Types A and C are considered to be primary, while types B and D are secondary, probably being intermediate forms.

In 1901, Brodel described a model of a pyelocaliceal system, having the anterior calyces in a position medial to the posterior ones (Brodel, 1901). Subsequently, Hodson also described a model, which mirrors the previously described one having the posterior calyces in a medial position and the anterior ones in a lateralized position (Hodson, 1972). This controversy ended in 1984 when Kaye and Reinke, after computed tomography observations, demonstrated that the Brodel-type kidney is found more often on the right side (69%), while the Hodson type is more frequent on the left side (79%) (Kaye and Reinke, 1984).

However, *in vivo*, due to the anterior rotation of the renal hilum, the anterior calyces are situated more laterally than the posterior ones in 74% of cases (Shnorhavorian and Anderson, 2004).

The renal pelvis can be intrasinusal or extrasinusal, having relations anteriorly with the renal vein and four segmental arteries, branches of the renal artery, and posteriorly with the fifth segmental artery.

2.3.1.1. Vascularization

The pyelocaliceal system's vascularization is ensured by branches of the superior ureteral artery and of the renal artery. Knowing the distribution of the terminal branches of these arterial sources is essential during intrarenal endoscopic interventions in order to choose the site for safely performing incisions or resections, as well as for evaluating the possibility of different complications.

Sampaio studied the relations between the pyelocaliceal system and the intrarenal arteries and veins, describing a model with very important endoscopic implications (Sampaio and Mandarim-de-Lacerda, 1988; Sampaio, 2007).

The upper pole arteries have their origins in the anterior branch of the antero-superior segmental artery. The upper caliceal group has close relations, both on the anterior and on the posterior sides, with segmental or interlobular arteries in 86% of cases, as well as with veins anastomosed into plexuses in 84.6% of cases.

For the mediorenal area, the arteries originate from the anterior branch of the renal artery, keeping a horizontal trajectory at the level of the renal pelvis, in its middle part. The middle calyces have anterior relations with a segmental or infundibular artery in 65% of cases and with a vein in 75% of cases. Posteriorly, at least one middle calyx has close relations with the middle branch of the posterior segmental artery (the retro-pyelic artery), and in 21% of cases with a venous branch tributary to the renal vein.

The arterial sources of the lower pole originate from the anterior branch (62.2%) or posterior branch (37.8%) of the renal artery. The lower calyces present, in all cases, anterior relations with a branch of the inferior or antero-inferior segmental artery, as well as with an intrarenal vein. In 32% of cases, this caliceal group has posterior relations with a branch of the posterior segmental artery, and in 21% of cases with a high caliber branch of the renal vein. Also, Sampaio described a venous ring around the lower secondary caliceal infundibula in an important percentage of cases.

In order to avoid vascular injuries, the incisions performed at the level of the pyelocaliceal system (in the treatment of stenoses or diverticula at this level) must be performed superficially (no deeper than 1–2 mm), over short distances and oriented longitudinally. These incisions should be made especially in the upper and/or lower quadrants and never at the anterior quadrant.

Sampaio reported the presence of an arterial and/or venous vessel in close contact with the uretero-pelvic junction's anterior side in 65% of cases (in 45% of cases represented by the inferior segmental artery). The posterior side of the uretero-pelvic junction is crossed by a significant caliber artery or vein in 6.2% of cases, while in another 20.5% of cases the ureter is crossed by vessels at 1.5 cm below the junction (Sampaio, 2007). Because of these relations, it is recommended to perform endoscopic incisions in the lateral or postero-lateral area of the uretero-pelvic junction, where the risk of intercepting an aberrant crossing vessel is very low.

2.3.2. The Ureter

The ureter, a paired organ, is a muscular duct located entirely retroperitoneal, stretching from the renal pelvis to the urinary bladder. The length of this segment of the upper urinary tract is approximately 22–30 cm, with variations from one individual to another and from one anatomical configuration to another. The right ureter is shorter by approximately 1 cm.

Along the trajectory of this organ, areas with an increased caliber have been described, called ureteral spindles (located in the lumbar and pelvic areas), where the diameter is between 5 mm and 10 mm (12–30 F), as well as narrower areas called straits, where the diameter ranges between 2 mm and 4 mm (6–12 F). Three straits are described as:

- superior – at the uretero-pelvic junction
- middle – at the crossing with the iliac vessels
- distal – at the uretero-vesical junction

2.3.2.1. Trajectory and Relations

The ureter has a downward inferior and medial trajectory, in the shape of the italic letter "S", both in the transverse and in the sagittal plane. There are three ureteral inflexions: at the level of the kidney, of the marginal flexure (intersection of the ureter with the terminal line), and of the pelvis. The distance between the ureter and the midline varies as follows: at the upper extremity – 4.5 cm, at the level of the marginal flexure – 3 cm, and at the uretero-vesical junction – 1 cm.

Depending on the relations with the sacrum, some authors describe three parts of the ureter as follows:

- upper – from the renal pelvis to the upper margin of the sacrum
- middle – from the upper to the lower margin of the sacrum
- lower – from the lower margin of the sacrum to the urinary bladder

Another classification divides the ureter into two parts:

- abdominal – from the renal pelvis to the upper edge of the pelvis
- pelvic – located entirely in the pelvis

The abdominal ureter includes a longer segment, of 14–16 cm, up to the iliac crest, called the lumbar part, and an iliac segment, at the level of the iliac vessels.

At its origin, the ureter comes into contact with the lower edge of the kidney (a reno-ureteral ligament has even been described), after which it has a trajectory anterior to the psoas muscle, which it accompanies up to the upper strait of the pelvis.

The lumbar part has the following anatomical relations:

- posterior – the psoas muscle, the lumbar transverse processes (at 1 cm medial to their extremities), and branches of the lumbar plexus (the femoral cutaneous and genito-crural nerves), which explains the irradiation of renal colic pain.
- anterior – with the parietal peritoneum, to which it is adherent and which separates it on the right side from the duodenum, pancreas, Toldt's fascia I, ileo-biceco-apendicular artery, and the terminal part of the mesentery; and on the left side, through Toldt's fascia II, from the superior left colic artery.

- medial – with the inferior vena cava to the right, and the aorta and the vascular arch of Treitze to the left.
- lateral – with the lower pole of the kidney, the ascending colon to the right, and the descending colon to the left, as well as with the genital vessels that originate from the abdominal aorta at the level of the L3 vertebra and which crosses the ureter posteriorly.

The iliac part of the abdominal ureter crosses the iliac vessels according to Luschka's law, at 1.5 cm below the bifurcation of the common iliac artery to the right and at 1.5 cm above this division to the left. Through the posterior parietal peritoneum, it has anterior relations with the terminal segment of the mesentery to the right and with the mesosigmoid and its vessels to the left, the ureter being located at the level of the upper edge of the sigmoid fossa.

The pelvic ureter is located in the extraperitoneal tissue, stretching from the upper strait of the pelvis to the opening into the urinary bladder through the ureteral orifices. It descends toward the posterior and lateral (parietal segment), passing anterior to the hypogastric artery and medial to the obturator artery and nerve. At the level of the ischial spine, it changes direction toward medial and anterior (visceral segment), being crossed anteriorly by the vas deferens in men and by the uterine artery at the base of the broad ligament in women, finally entering the bladder wall (intramural segment). The submucosal trajectory of the ureter is approximately 2 cm long and it ends at the ureteral orifice (Gray, 1994).

2.3.2.2. Vascularization and Innervation

The ureter has a complex, segmental vascularization, its various parts being vascularized by nearby vessels.

For the abdominal part, the arterial vascularization is ensured by the superior ureteral artery (originating from the prepyelic artery, a branch of the renal artery) and the middle ureteral artery (a branch of the aorta, of the testicular/ovarian artery, or of the common iliac artery). In the pelvic part, the vascularization is ensured by the inferior ureteral artery (a branch of the superior vesical artery or of the artery of vas deferens in men, respectively of the uterine artery in women). All of these arterial sources present multiple anastomoses, creating a periureteral arterial plexus. In the upper part of the ureter, the arterial sources are arranged medially, while the lower part receives the arterial sources from the lateral. This disposition, as well as the relations of the various ureteral segments, should be considered when performing endoscopic incisions.

The venous blood is drained into vessels corresponding to the arteries, which flow into the inferior cava vein, the iliac veins, and the latero-vesico-genital plexus.

The lymphatic system represents a submucosal network of capillaries, from this level the lymph being drained through collecting trunks toward the para-aortic, lumbar, and iliac lymph nodes.

The innervation of the ureter is provided by nervous threads coming from the renal, testicular (or ovarian), and hypogastric (in the pelvic part) plexuses and which reach the ureter along the blood vessels. The afferent fibers accompany the sympathetic nerves and enter the spinal cord at the first two lumbar segments. In the ureteral wall, there are groups of vegetative cells forming intramural lymph nodes.

2.4. Endoscopic anatomy of the upper urinary tract

Knowing the endoscopic anatomy of the upper urinary tract is essential for performing diagnostic and therapeutic ureteroscopies in adequate conditions.

Immediately after inserting the endoscope into the bladder, the bladder trigone becomes visible, delimited between the posterior lip of the cervix and the two ureteral orifices. Its base is represented by a prominent area called the interureteral bar (Fig. 2.1) and it extends between the two orifices.

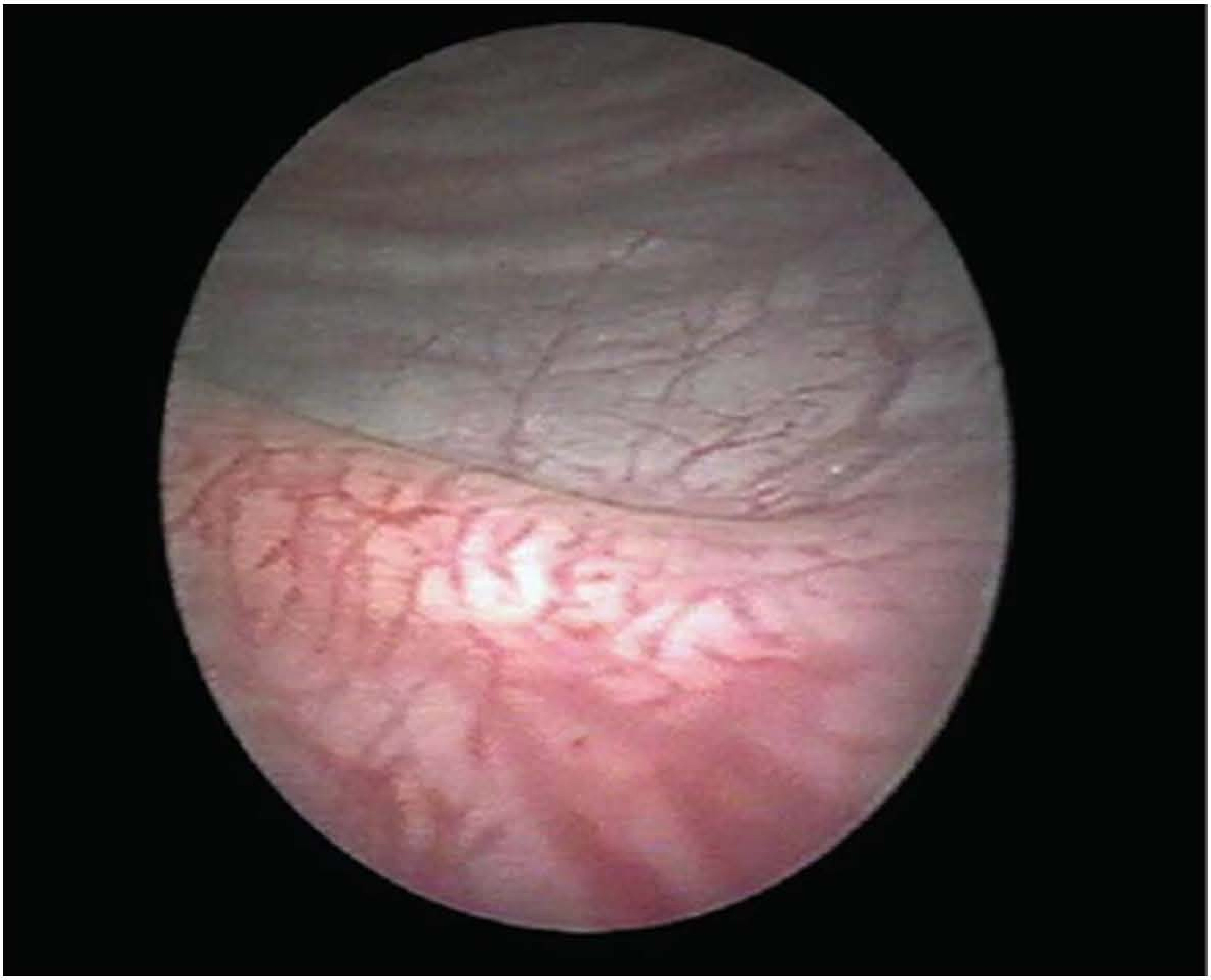
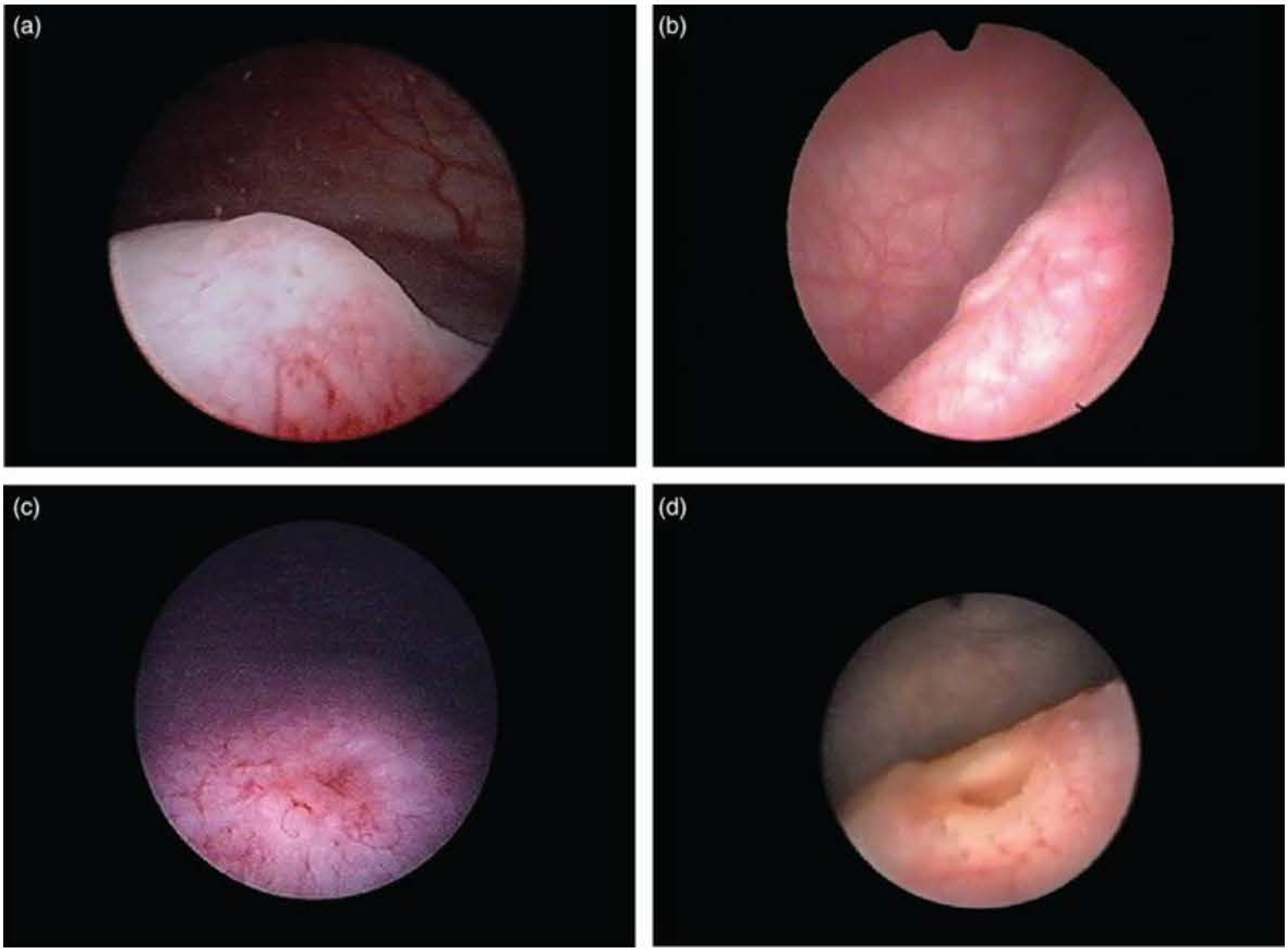


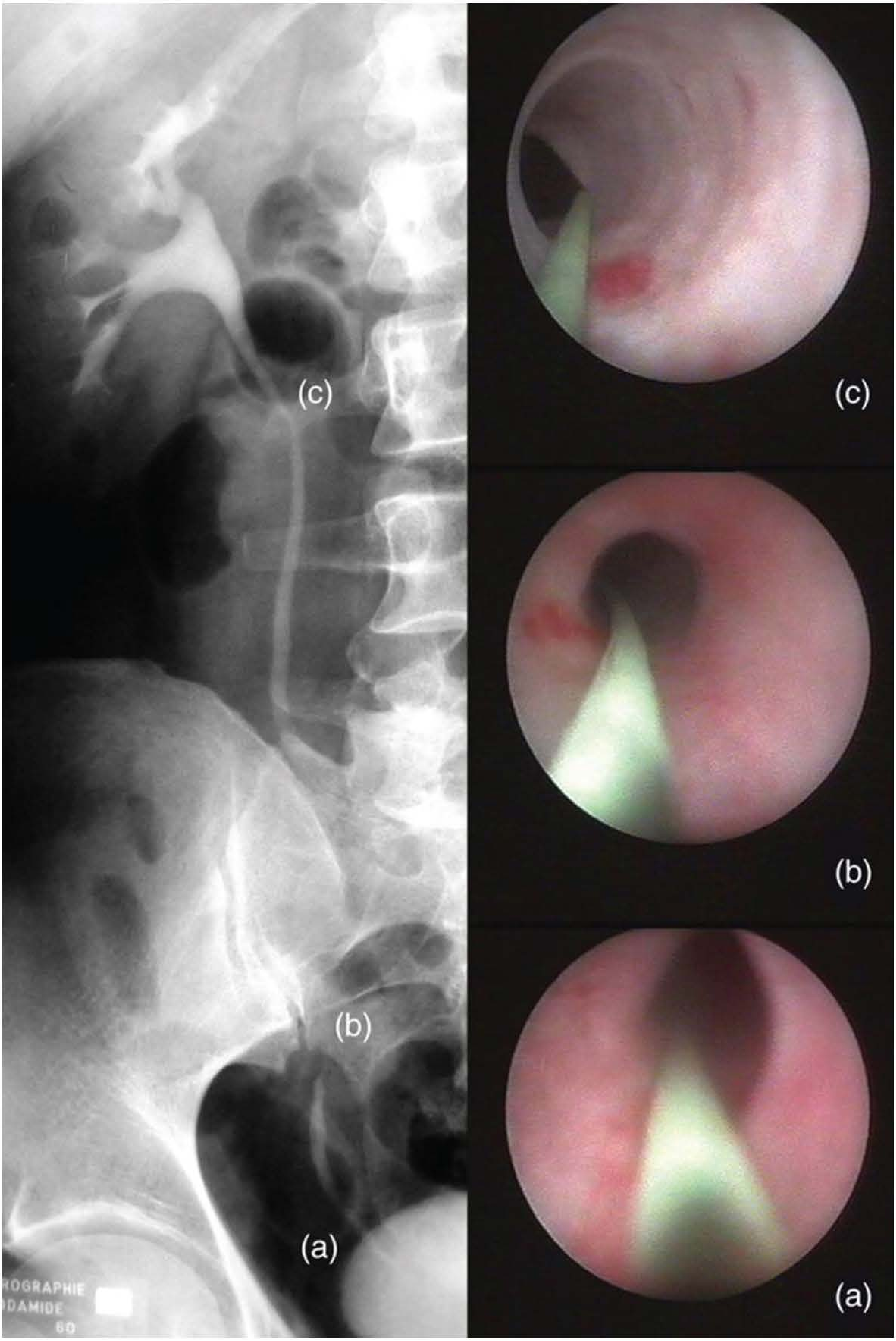
Figure 2.1 **Endoscopic aspect of the interureteral bar.**

In 1969, Lyon, Marshall, and Thanago classified the ureteral orifices according to their aspect (Fig. 2.2) as follows:

- grade 0 – orifices with normal cone or “volcano” aspect
- grade 1 – stadium-shaped orifices
- grade 2 – “horseshoe” orifices
- grade 3 – “golf-hole” type orifices



minimal (1.5–3 mm), requiring its dilation when ureteroscopes with a larger caliber are used.


(c)
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(c)
(b)
(a)

Figure 2.4 **Radiological (left) and endoscopic (right) aspect of the three ureteral straits: intramural ureter (a), iliac region (b), and uretero-pelvic junction (c).**

The second strait (Fig. 2.4), where the ureteral caliber is of approximately 4 mm, is situated in the area where it crosses the iliac vessels. This crossing represents an important landmark in ureteroscopy, the iliac artery pulsations being observed postero-internally through the ureteral wall.

The next segment, with a relatively straight trajectory, is represented by the part located on the psoas muscle. The proximity to the proximal ureter is suggested by its synchronous movements with breathing. These are secondary to the diaphragmatic excursions, which determine the descending or ascending of the kidneys.

The third strait (Fig. 2.4) is represented by the uretero-pelvic junction (2–4 mm), the renal pelvis being located superior to it. A postero-lateral fold may be visible at the junction, exacerbated by the respiratory movements.

The degree of the straits observed at endoscopy varies from one individual to another. Thus, there are situations in which these areas cannot be detected, while in other cases the strait is so narrow that it does not allow the instruments to pass without prior dilation. The areas of the ureter with a narrow caliber can stop the passage of calculi, and can also raise significant problems during the ureteroscope's ascent. In such cases, the ureteroscope may telescope the ureteral wall while advancing, and its aggressive handling can lead to avulsions or perforations.

In addition, retroperitoneal fibrosis, idiopathic or consecutive to retroperitoneal surgery or to radiotherapy, causes ureteral wall rigidity, thus limiting the possibility of their distension.

Ureteral spasm is also involved in the possible segmental narrowing of the lumen, observed during ureteroscopy. Short, fibrous segmental narrowing can be dilated with balloon probes. Various pharmacological agents such as glucagon, aminophylline, and lidocaine gel can remit the ureteral spasm.

The renal pelvis has most often a conical shape, with the tip toward the uretero-pelvic junction. After ascending the ureteroscope into the pelvis, the circular ostia of the major calyces become visible (Fig. 2.5), separated by prominent areas called carinas (Fig. 2.6).

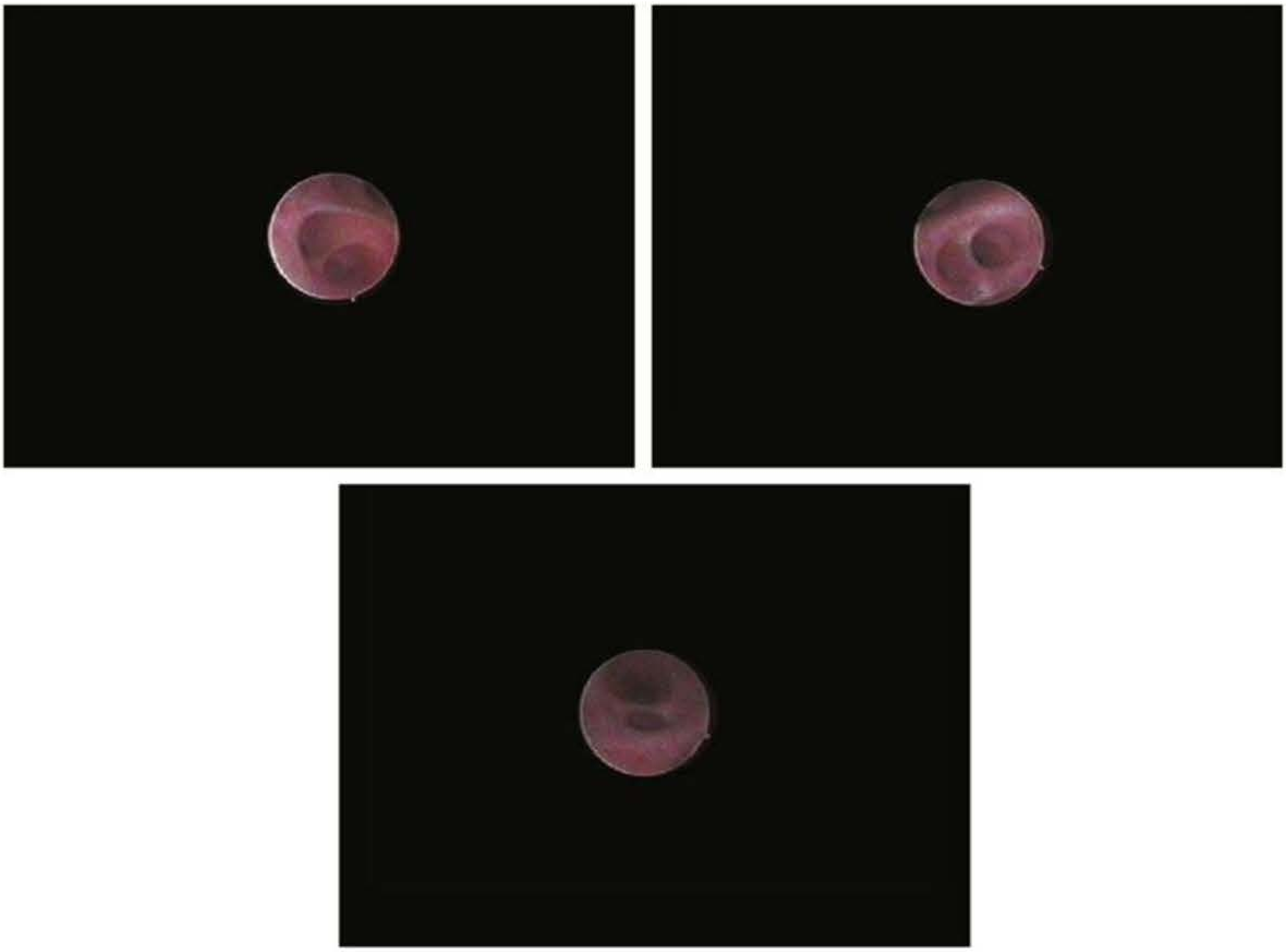

Figure 2.5 **Flexible ureteroscopic appearance of the major calyces' ostia, with the minor calyces visible in the background.**

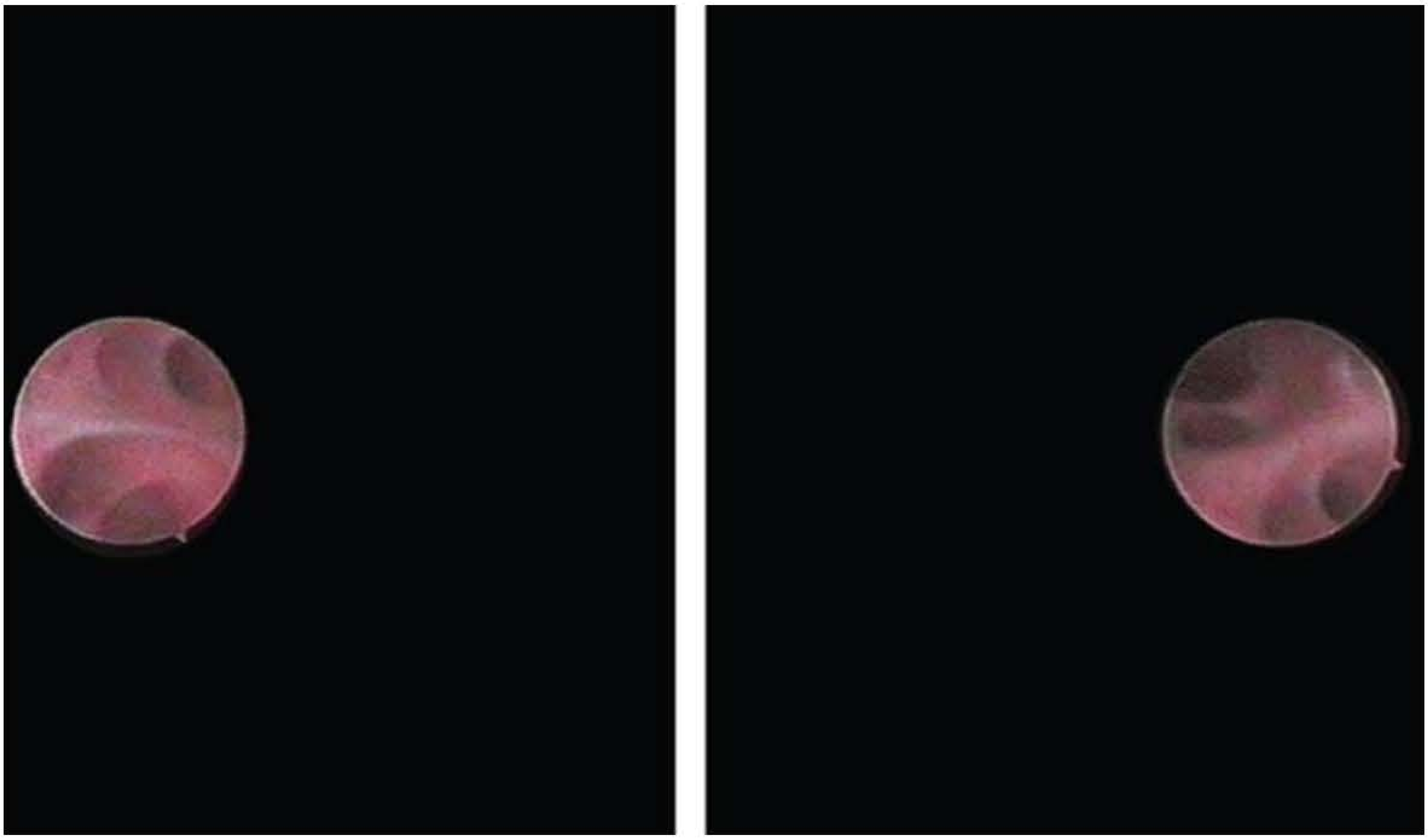

Figure 2.6 **Endoscopic aspect of the carinas that separate the ostia of the major calyces.**

The renal pelvis situated intrarenally is usually small, with short caliceal infundibula, while the extrarenal pelvis is wide, with long caliceal infundibula. The infundibula of the major calyces branch (Fig. 2.7) into minor or secondary calyces (Fig. 2.8).

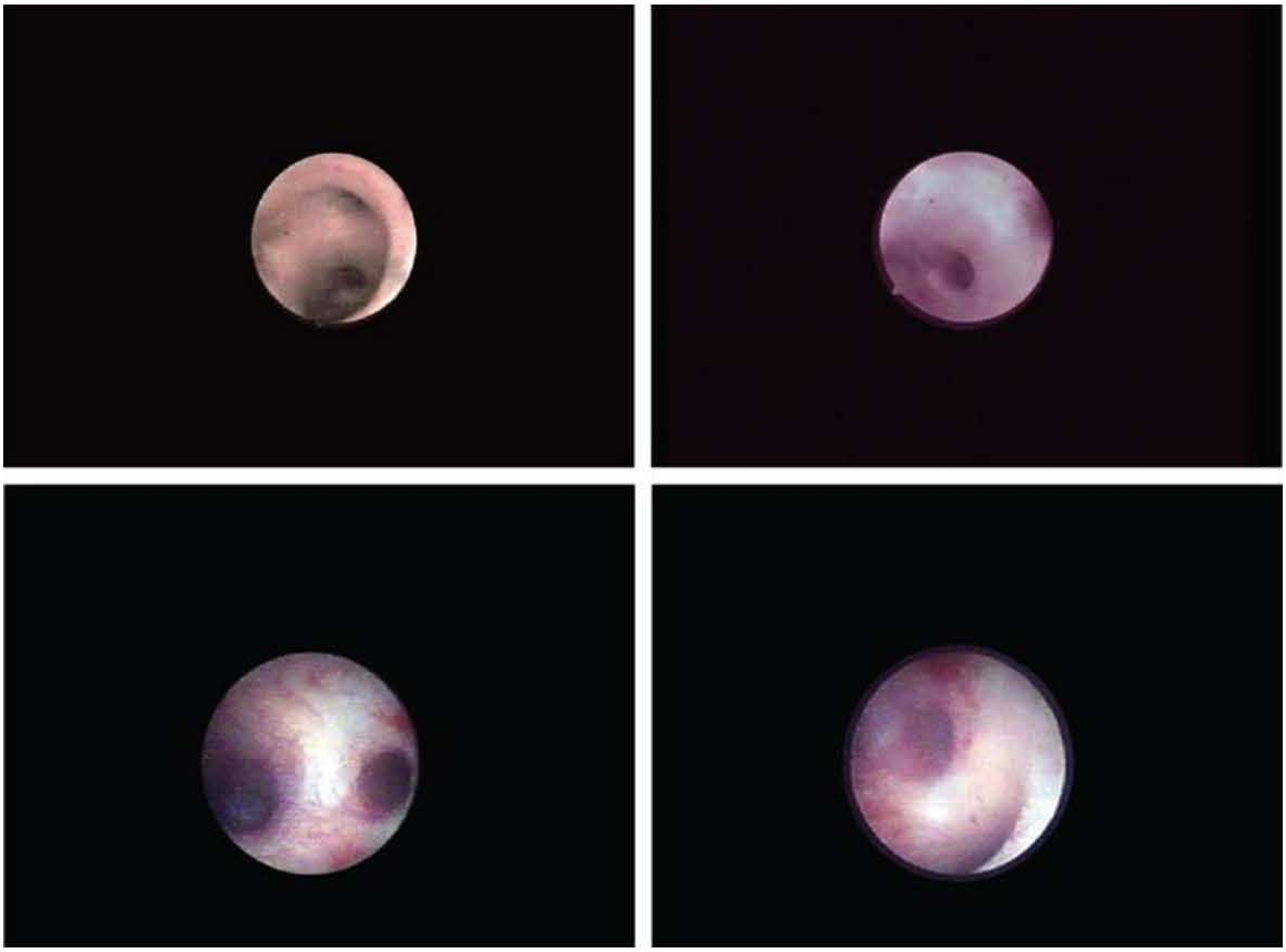

Figure 2.7 **Ostia of the minor calyces visible from the level of a major calyx.**

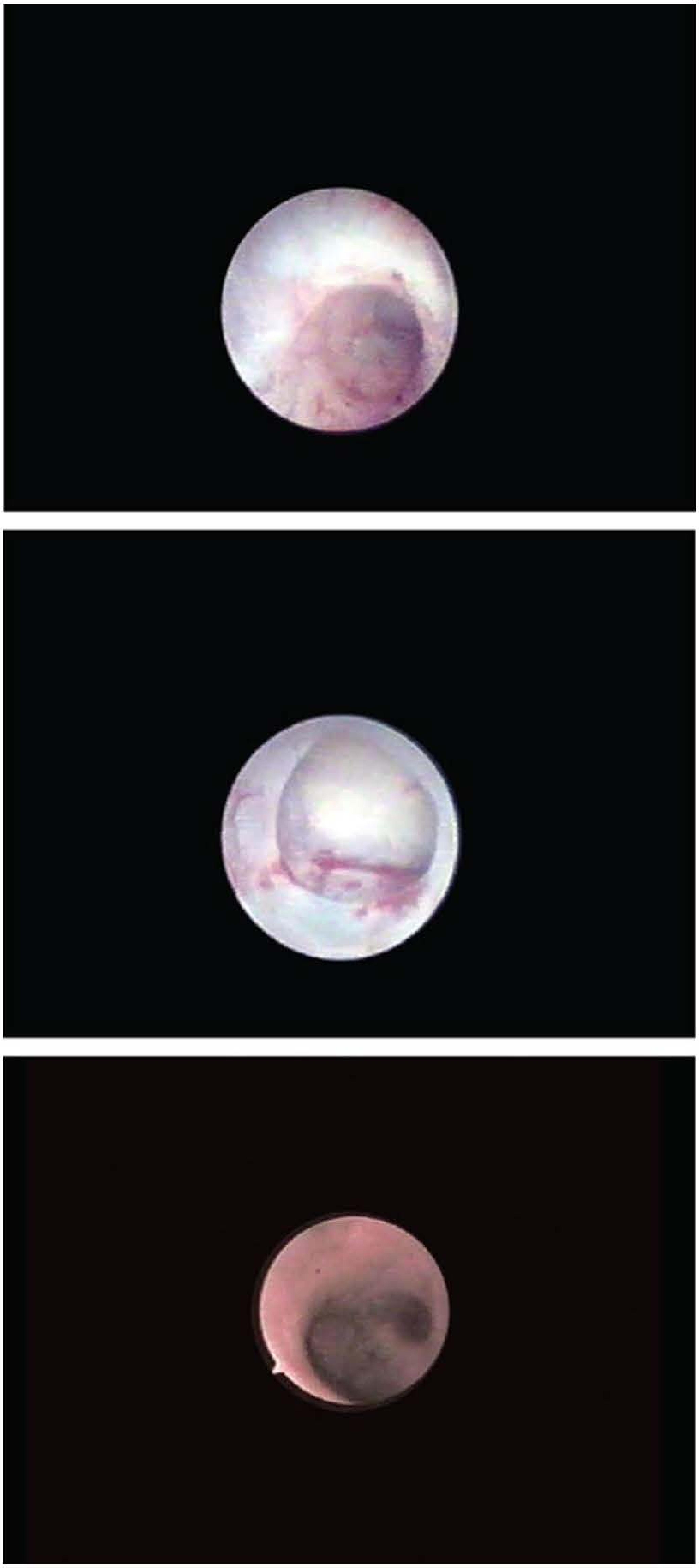

Figure 2.8 **Endoscopic aspects of minor calyces.**

Renal papillae are visible at the end of these calyces during endoscopic examination. They are usually disk-shaped (Fig. 2.9) or cone-shaped (Fig. 2.10), being covered by a pink mucosa with striations converging toward the center.

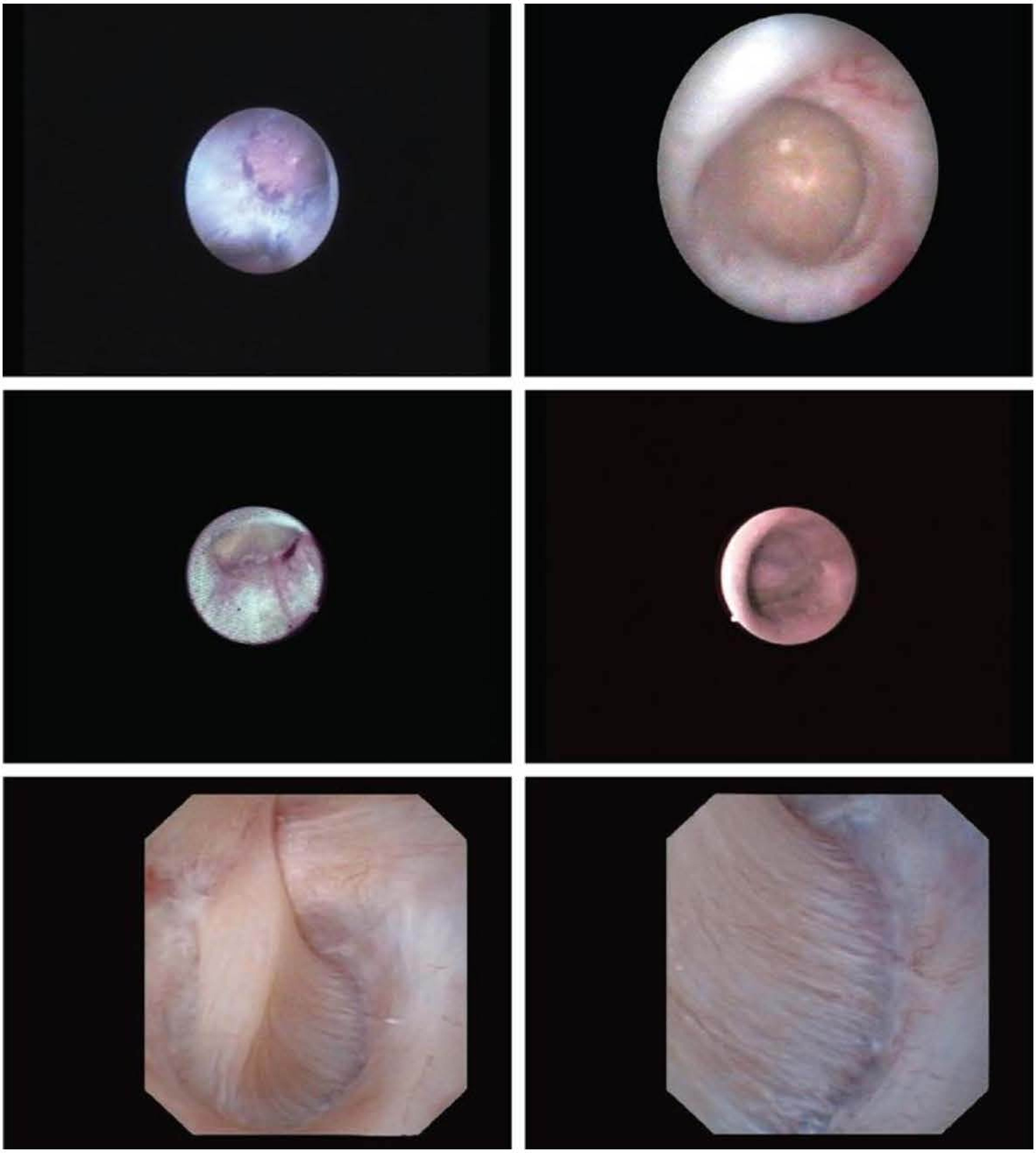

Figure 2.9 **Ureteroscopic aspects of renal papillae.**

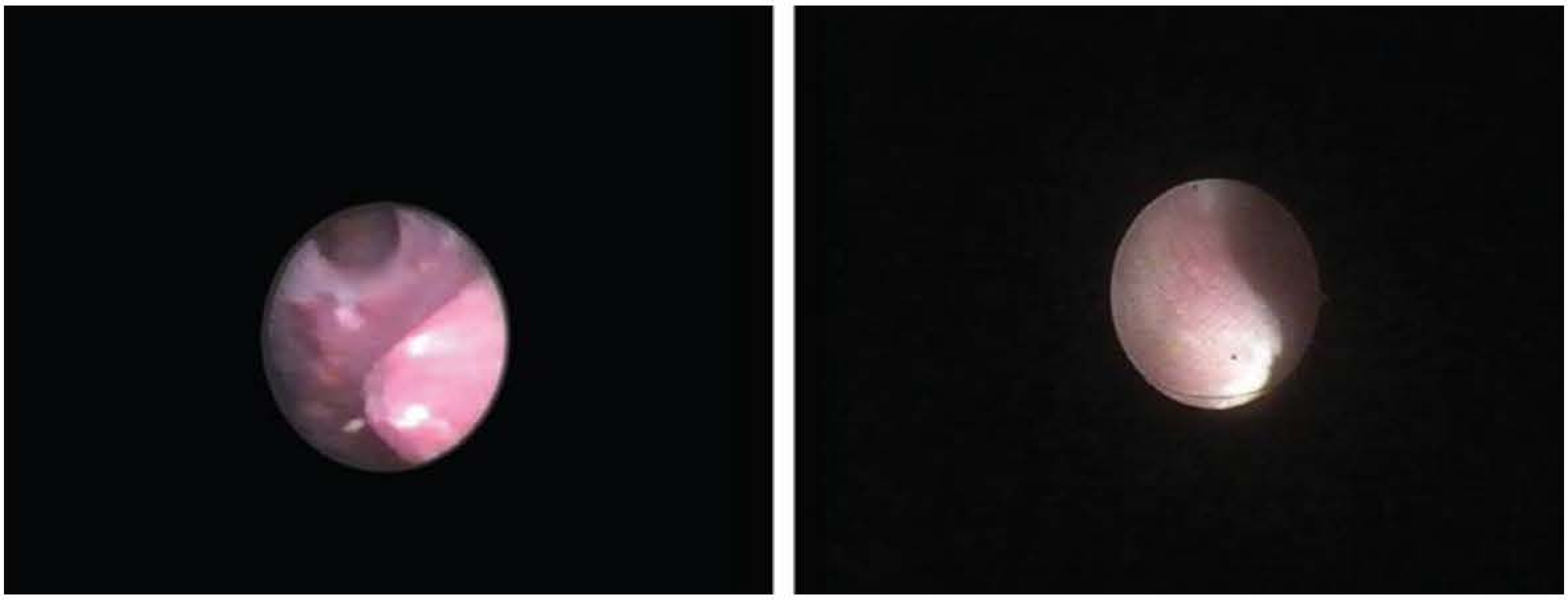

Figure 2.10 **Cone-shaped hypertrophic renal papillae.**

At the periphery of the papilla, there is a paler mucosal ring: the papilla fornix. Several papillae can open into a secondary calyx. These are called complex papillae (Fig. 2.11).

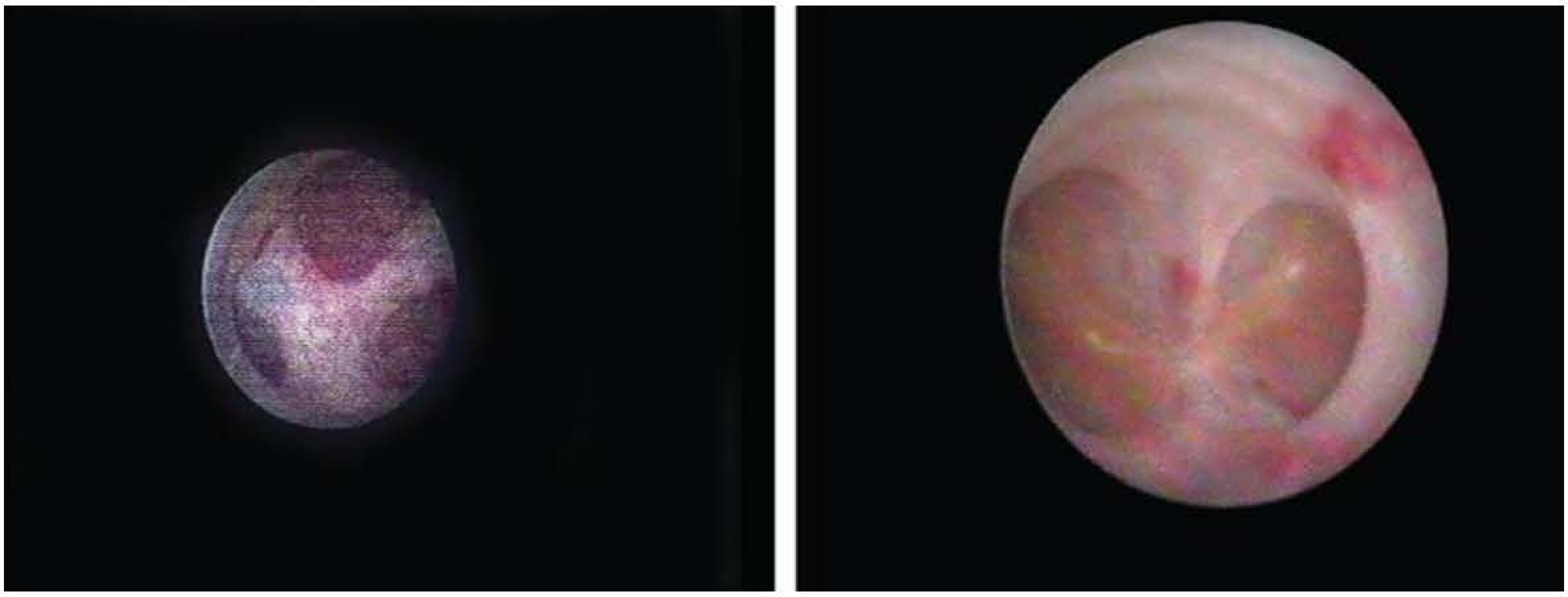

Figure 2.11 **Complex renal papillae.**

An important anatomic parameter for flexible retrograde ureteroscopic approach is the infundibulo-pyelic angle (Geavlete et al., 2007). This is the angle between the axis of the upper part of the ureter and the axis of the lower calyx infundibulum (Fig. 2.12), being equivalent, in practice, with the amplitude of the flexible ureteroscope's deflection during the approach of this caliceal group. The average value of this angle is 40° and it inversely correlates with the difficulty of the flexible ureteroscopic approach of the lower calyx.

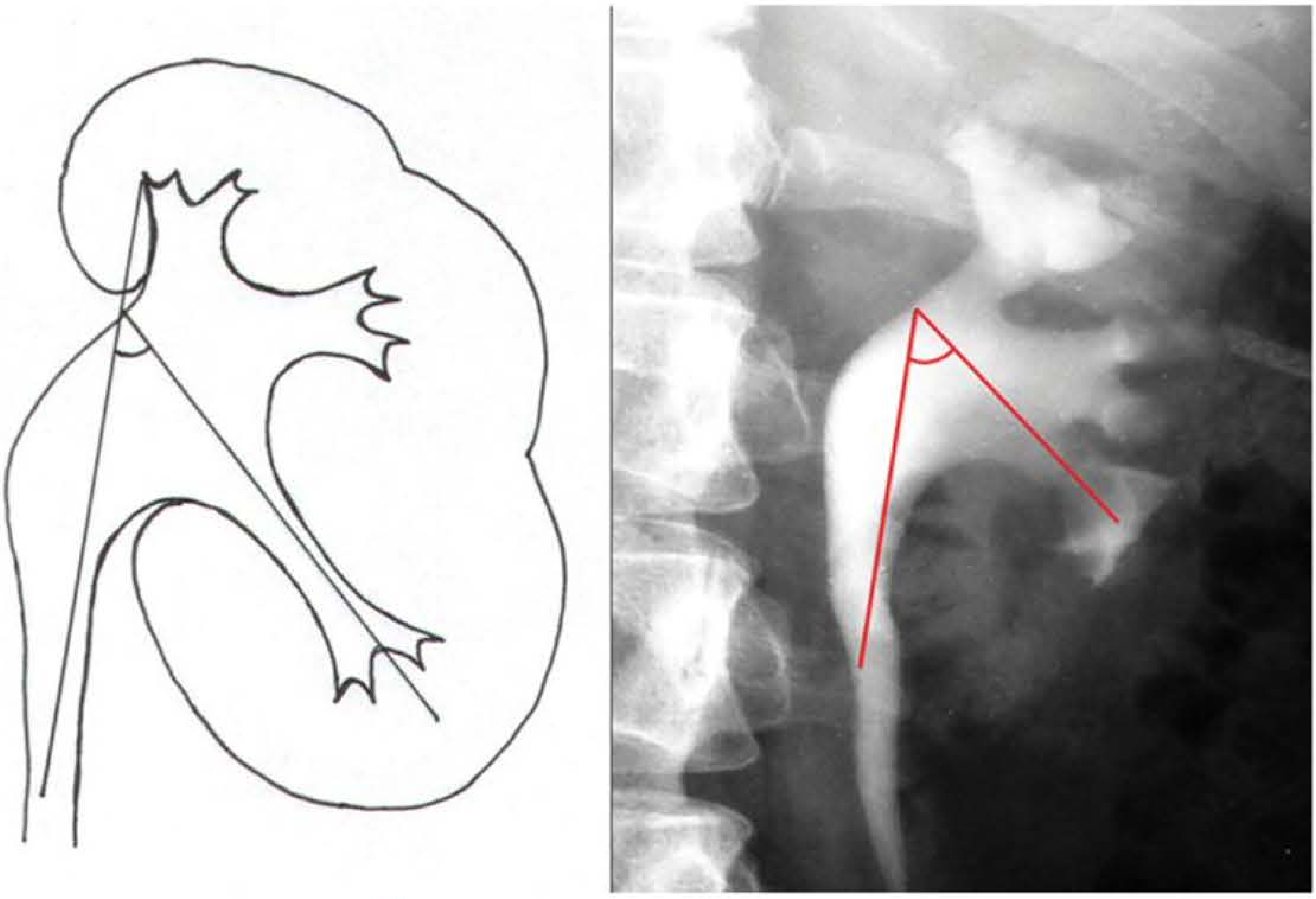

Figure 2.12 **Infundibulo-pyelic angle.**

2.5. Upper urinary tract physiology

The efficiency of urine transportation from the kidney to the bladder is dependent on the ureteral functionality.

Under normal circumstances, the peristaltic waves ensure the propulsion of the urinary bolus toward the bladder. As the urine is collected in the renal pelvis, the pelvic pressure increases and initiates a peristaltic contraction that is propagated along the ureter to the bladder. The peristaltic wave can move urine against an obstacle, with a pressure of up to 50–100 mm Hg.

Ureteral wall coaptation no longer occurs in case of an increased urinary flow; urine transportation being achieved through a continuous column rather than a series of boluses.

Inadequate urine transportation can be determined either by an important increase or decrease of the ureteral urinary flow (Griffith, 1983).

Under normal circumstances, ureteral peristalsis is determined by the electrical activity of the pacemaker centers ("pacemaker sites") located in the proximal portion of the urinary collecting system (Constantinou and Djurhuus, 1981). Electrical activity propagates distally and generates mechanical peristaltic waves, ureteral contractions that propel urine distally. The transmission of the peristaltic wave occurs due to an action potential that is propagated along the syncytial smooth muscle of the ureteral wall.

The ureteral smooth muscle fiber is the first anatomic and functional ureteral unit. The muscle cell is very small, approximately 250–400 µm in length and 5–7 µm in diameter. In all excitable tissues, the electric properties depend on the distribution of ions on both sides of the cell membrane. The basis for the electrical activity in the ureteral smooth muscle cell has not been fully deciphered, but many of the properties are similar to those from other excitable tissues.

Ureteral peristalsis also persists after transplantation or denervation, the spontaneous activity also occurring in the ureteral segments isolated *in vitro*. Normal antegrade peristalsis also continues after inversing a ureteral segment *in situ*. These findings lead to the conclusion that ureteral peristalsis is not dependent on innervation. However, analysis of the published data indicates the fact that the nervous system plays at least a modulatory role in ureteral peristalsis. The existence of muscarinic and adrenergic receptors in the ureter has also been demonstrated. Some authors consider that this autonomous ureteral motility is due to the existence of intramural nerve plexuses that are under the influence of sympathetic and parasympathetic innervation. Parasympathetic stimulation can increase, while sympathetic stimulation may decrease, the frequency of peristaltic waves and can probably affect the intensity of contraction. Thus, the sympathetic system generally has a relaxing effect on the ureteral smooth muscles, while the parasympathetic system has a stimulating role.

The ureter is well innervated, an increased density of nerve fibers that transmit painful stimuli being highlighted at this level. The emergence of an obstacle in the ureter, by stimulating pain receptors, produces an intense constrictor effect on its musculature. In addition, the pain impulse determines a sympathetic reflex at the kidney level, with arteriolar vasoconstriction, thus decreasing urine formation in the kidney. This mechanism is called the uretero-renal reflex.

In the lower part, the ureter obliquely enters the bladder and passes several centimeters beneath the urothelium, so that the intravesical pressure compresses the ureter, preventing the reflux of urine during micturition. The ureteral functionality has important implications in the ureteroscopic approach. The hydration of the patient or the use of diuretics increases urinary flow and the frequency of the peristalsis (Morales et al., 1952). The increase of urinary flow helps maintain the clarity of the endoscopic field. In 1987, Eshghi and colleagues evaluated the physiological effects of irrigation during ureteroscopy (Schwalb et al., 1993). Retrograde pressure is determined according to Laplace's law:

$$\text{Pressure} = \text{Parietal tension} / \text{Radius}$$

The study suggested that pressures of over 200 cm H_2O may determine kidney damage, if exerted over a period of time longer than 30 min.

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Chapter 3

3.1. Generalities

The instruments used for the ureteroscopic approach of upper urinary tract conditions are in a continuous evolution. The first ureteroscopes were too large in diameter, their use being restricted to a small number of patients. Moreover, the methods for stone fragmentation or extraction, as well as for tissue resection/fulguration, were limited. Subsequently, the instruments evolved and the technique improved, the ureteroscopes allowing the use of an increasing number of accessory instruments, in the conditions of a decreasing diameter.

Recently, both rigid and flexible ureteroscopes have undergone many improvements in order to increase their efficiency, durability, and to gain the ability of using specific working instruments. Most of the ureteroscopes that are currently in use have dimensions that allow them to be ascended without requiring dilation of the ureteral orifice. A large number of accessory instruments may be used for rigid ureteroscopes, as well as for flexible ones.

The development of rigid and flexible ureteroscopes with increasingly smaller dimensions determined the diversification of transurethral upper urinary tract endoscopy.

The quality of the optical system is extremely important for the endoscopes' efficiency (Nicolescu, 1997). There are two types of optical systems:

- rigid optical systems
- flexible optical systems

The rigid optical systems include a lens that is placed at the distal end of the telescope, a lens system that flips the image, and a viewfinder fitted with a lens. The fixation system of the cylindrical lenses (Hopkins), in the detriment of the serial position, has made it possible to lower the number of optical interfaces, which has led to a decrease of diffraction, to an increase of light transmission, and to an increase of resolution and color fidelity.

The fiberglass light conductor is built parallel with the lenses fitted in the telescope. The viewing angle of the telescope is determined by the ratio between its central axis and the angle obtained at production (0–120°).

In the case of flexible instruments, the transmission of light is achieved through total internal reflection within the optic fascicles. The materials used to make the flexible optical conductors must have different refraction indexes between the central and the peripheral part. The optical fibers are fabricated in parallel bands and lead the image from the distal lens' focal point to the proximal end of the telescope, the viewfinder. The viewing angle is calculated by the ratio between the instrument's 0° axis and the viewfinder's degree of flexion related to this axis.

The flexible instruments have a lower reliability due to the high risk of breaking the optical fibers, the reduction in the quality of the images being directly proportional to the amount of broken optical fibers. This fact leads to the requirement of frequent instrument inspection for the early detection of the decrease in illumination and visualization capability.

3.2. Rigid ureteroscopes

Rigid ureteroscopy can be performed retrogradely, by inserting the endoscope through the ureteral orifice after a prior dilatation of the intramural segment of the ureter or antegradely, by inserting the endoscope through the percutaneous nephrostomy tract and subsequently, through the pyeloureteral junction, into the ureter.

The ureteroscopes, optical instruments intended for the diagnosis and treatment of upper urinary tract disorders, have a caliber that fits in the internal circumference of the dilated ureter. According to Matoushek's description, the ureteroscope is similar in design "to an elongated pediatric endoscope."

Rigid ureteroscopes (Fig. 3.1) are ideal for interventions at the distal ureter, being easy to maneuver and providing very good control of the working instruments. The technical progress and improvement of design have also allowed for their use in the proximal ureter and renal pelvis. Classically, the rigid ureteroscopes used cylindrical lens systems. The modern endoscopes involve the use of optic fibers that allow a significant reduction of dimensions, with an increase of durability and with the prevention of image distortion. However, even now, the images obtained by using optic fibers do not equal the quality of those obtained through cylindrical lens systems.

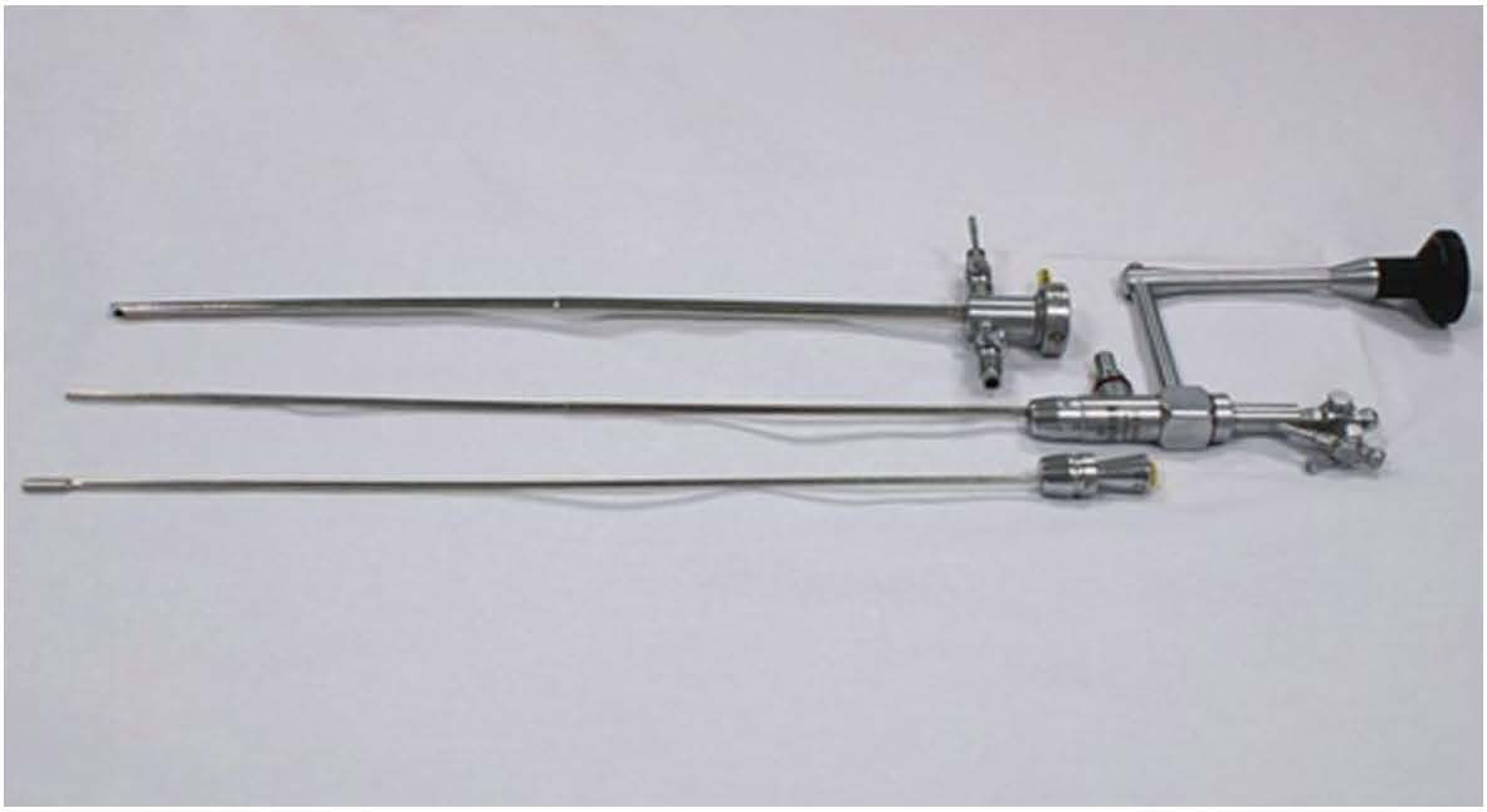

Figure 3.1 **A 12 F rigid ureteroscope.**

3.2.1. External Configuration

Regarding their dimensions, the classic rigid ureteroscopes had calibers between 13 F and 16 F. The larger caliber endoscopes have the advantage of a wider working channel and, implicitly, superior irrigation and visibility.

However, due to the diameter of over 10 F, the use of these instruments requires the dilatation of the ureteral orifice (Bagley, 1994), increasing the aggressiveness to the tissues.

The incidence of secondary ureteral stenoses after ureteroscopic maneuvers is in direct correlation with the dimensions of the endoscope.

Huffman (1989) described a rigid ureteroscope with a cylindrical lens system, with an external diameter of 8.5 F and a working channel of 3.5 F.

Regarding the distal end's design, the first ureteroscopes copied the design of cystoscopes, determining difficulties in approaching the intramural ureter. Resolving this issue subsequently led to the development of ureteroscopes with a conical end (Fig. 3.2).

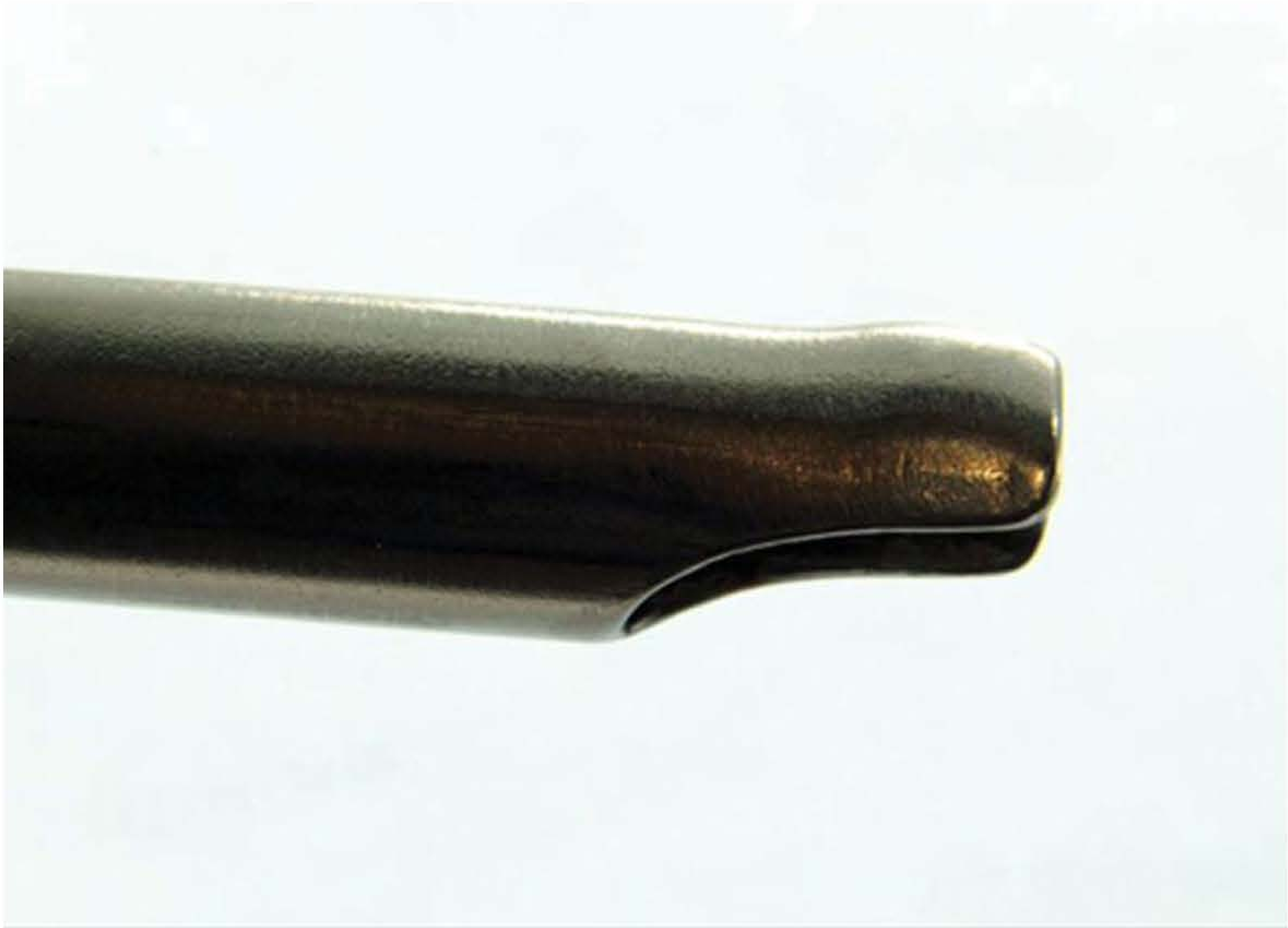

Figure 3.2 **The conical design of the distal end of the ureteroscope.**

The uretero-resectoscopes (Fig. 3.3) have in addition a mobile working element, similar to that of resectoscopes used for low endourological interventions.

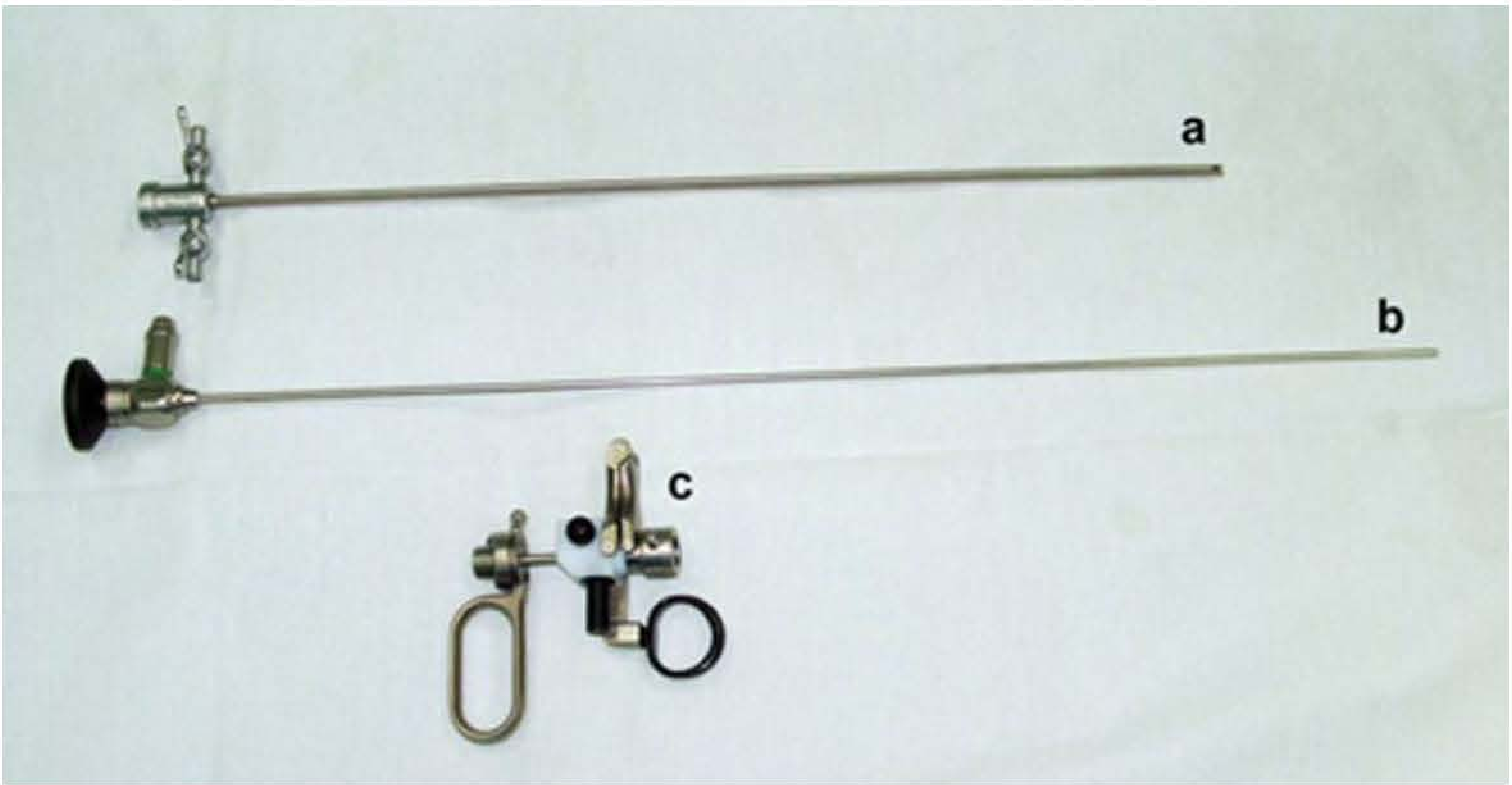

Figure 3.3 **Uretero-resectoscope components.**
(a) External sheath, (b) telescope, and (c) mobile working element.

3.2.2. Optical Systems

The use of rigid optical systems determines distortions in the transmission of light when bent. This phenomenon determines the reduction of the visual field by up to 50% (Miller et al., 1986). Applying a torsion force during the approach of the distal ureter may lead, in time, to damaging the optical system.

Rigid ureteroscopes with interchangeable telescope sets have been produced. This allows for an increase of the visual field, and 0–70° optical systems can be used in the same sheath. Due to the large caliber of the sheaths (13–16 F), the subsequent models included integrated telescopes with a visual angle varying between 0° and 6.5°, allowing the ureteroscope's diameter to be reduced while maintaining a sufficient working channel (3.5–5 F). Obtaining a visual angle of 6.5° allows for an easier orientation of the instruments when emerging from the working channel.

3.3. Semirigid ureteroscopes

With the technological evolution, the rigid ureteroscopes have been largely replaced by semirigid ureteroscopes (Fig. 3.4). These include a high-density optic fiber fascicle, enclosed in a semirigid metallic sheath. The use of these fibers has determined the reduction of the space necessary for the optical component of the ureteroscope, allowing the incorporation of a large working channel, despite a low external diameter.

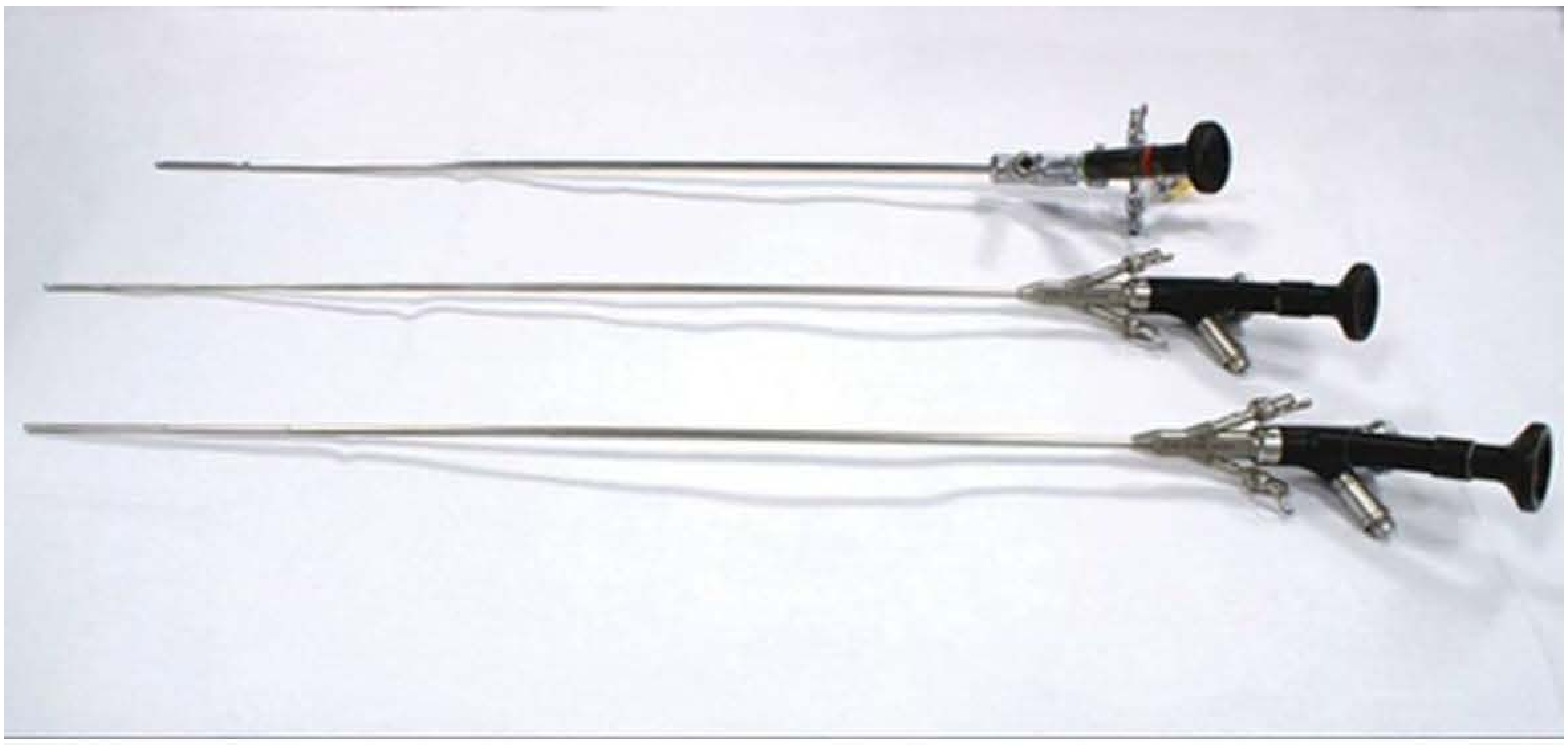

Figure 3.4 **Different models of semirigid ureteroscopes.**

The optic fiber fascicle allows a vertical flexibility of the endoscope, without creating image distortions.

3.3.1. External Configuration

Usually, the distal end of semirigid ureteroscopes has a diameter between 6 F and 10 F. These dimensions allow performing ureteroscopic maneuvers without dilation of the intramural ureter. The sheath of most semirigid ureteroscopes has a progressively increasing diameter from the distal to the proximal end, where it reaches a caliber varying between 7.8 F and 14.5 F. This design facilitates the progressive dilatation of the ureter as the ureteroscope is advanced. The working length of the models used in practice is of over 31 cm. This length allows the approach of the distal and middle ureter, and in women it is sufficient to also approach the renal pelvis. For ureteroscopic interventions on the pyelocaliceal system in men, an endoscope's length of approximately 40 cm is required.

The distal end of semirigid ureteroscopes has a circular or oval configuration (Fig. 3.5). Recently, ureteroscopes with a triangular end have been described (Fig. 3.6), facilitating the approach of the ureteral orifice.

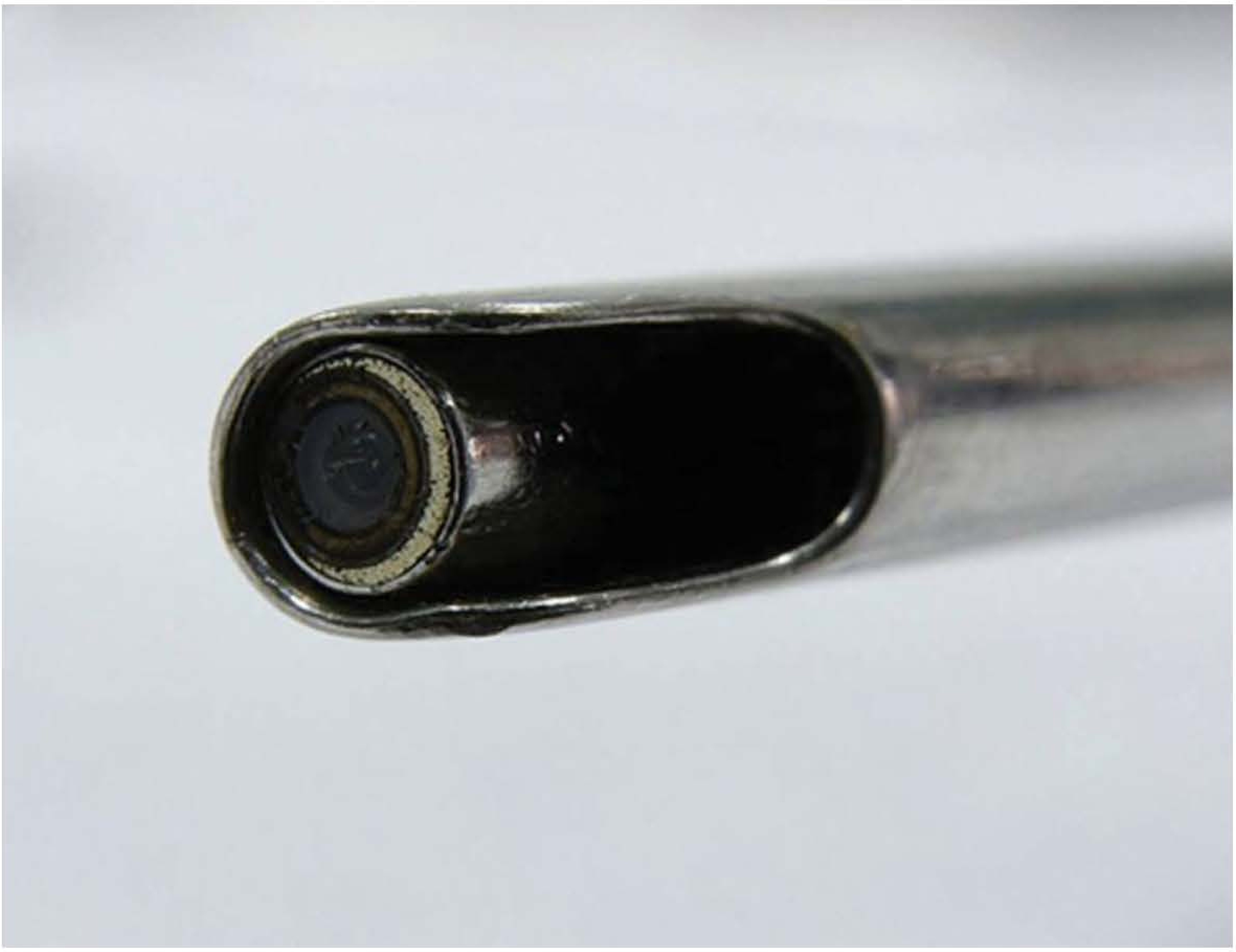

Figure 3.5 **Oval profile of the distal end of the semirigid ureteroscope.**

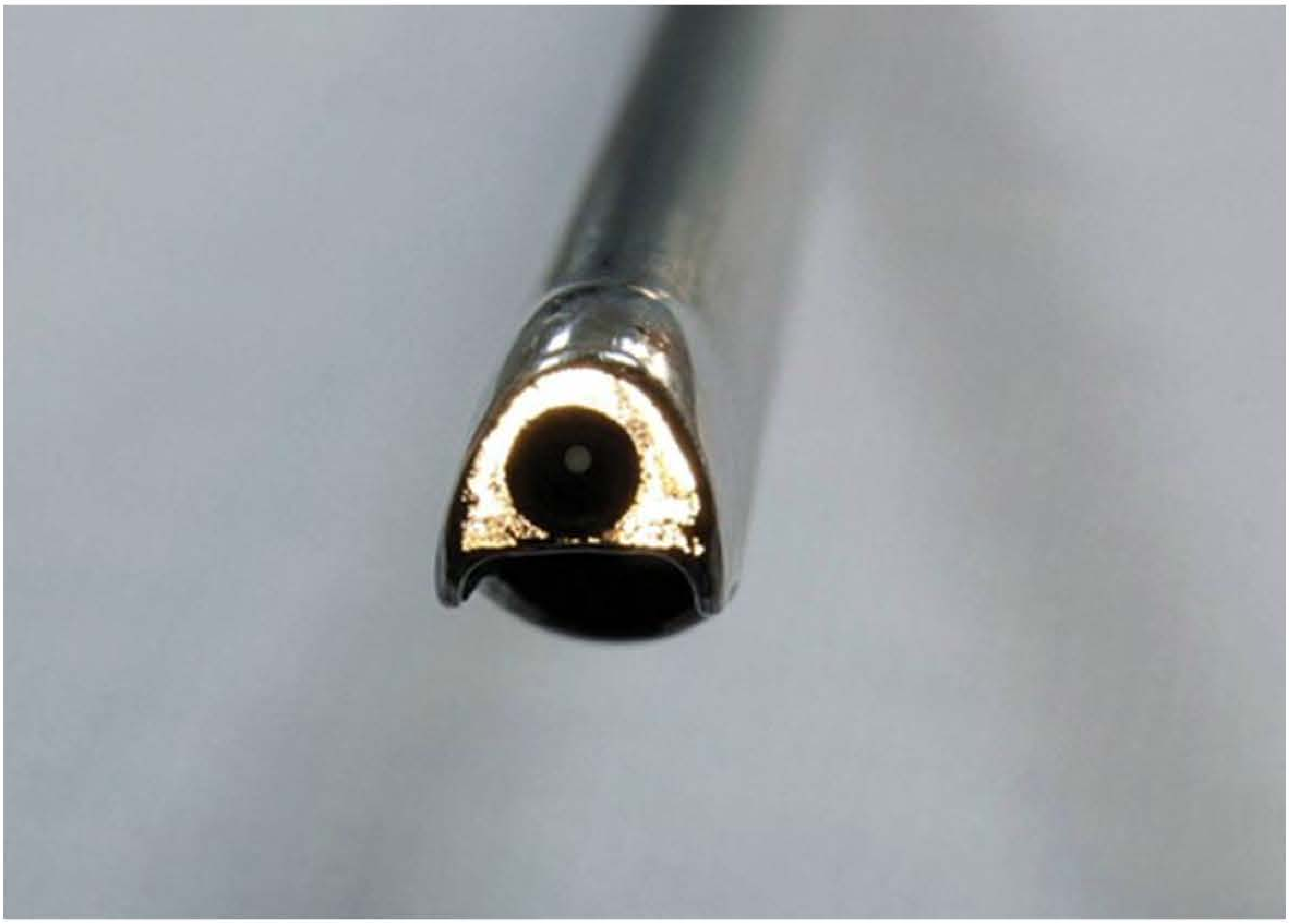

Figure 3.6 **Triangular distal end of the semirigid ureteroscope.**

3.3.2. Optical Systems

The optical systems of semirigid ureteroscopes include optic fibers similar to those used in flexible instruments. Due to the relatively large diameter, these instruments contain a large number of fibers, ensuring a higher image quality.

Initially, the image offered by these instruments had a low quality due to the low resolution and the "honeycomb" aspect produced by the optic fibers. The modern fiber layout and the progress of the video systems have solved these problems (Kuo and Preminger, 2001).

Due to the flexibility of the optic fiber systems, these ureteroscopes can be angled, while at the same time ensuring a straight working channel that is necessary for rigid working instruments. Furthermore, the physical properties of this type of optical system allow the positioning of the viewfinder in the axis of the instrument, as well as eccentric to it (Fig. 3.7).

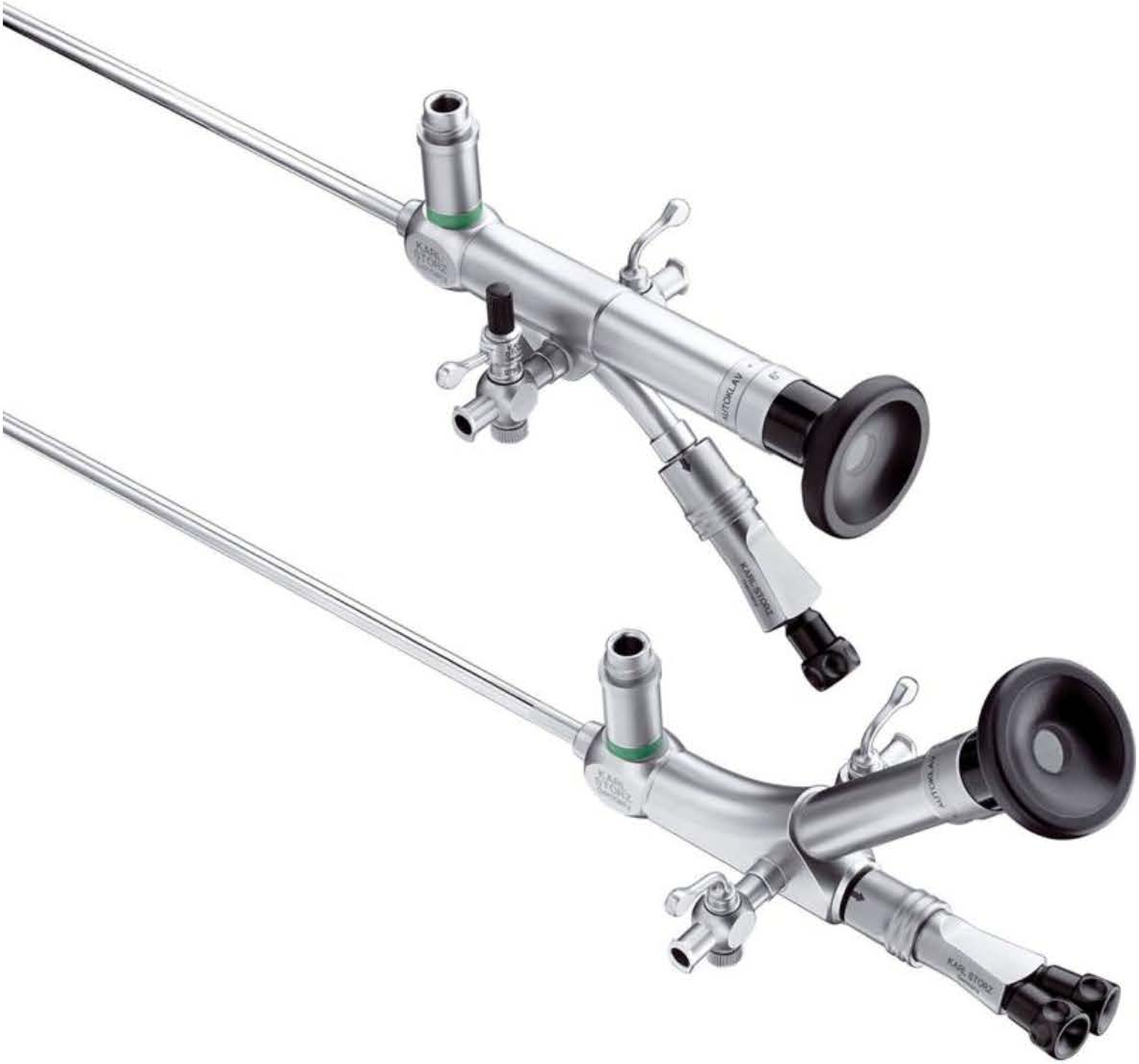

Figure 3.7 Semirigid ureteroscopes with the viewfinder positioned in the axis of the instrument (top) or eccentric to it (bottom).

In recent years, in the attempt to optimize the endoscopic image, digital semirigid ureteroscopes have been developed (video-ureteroscopes). These have at the distal end a CMOS- or CCD-type sensor that receives the information and transmits it in a digital format.

3.3.3. Working Channel

The working channel of modern semirigid ureteroscopes has a caliber between 2.1 F and 6.6 F. In general, the ureteroscopes have at least one channel with a diameter of 3.4 F that allows the passage of most accessory instruments, as well as a proper irrigation (Fig. 3.8). Today, semirigid instruments with two working channels are usually used.

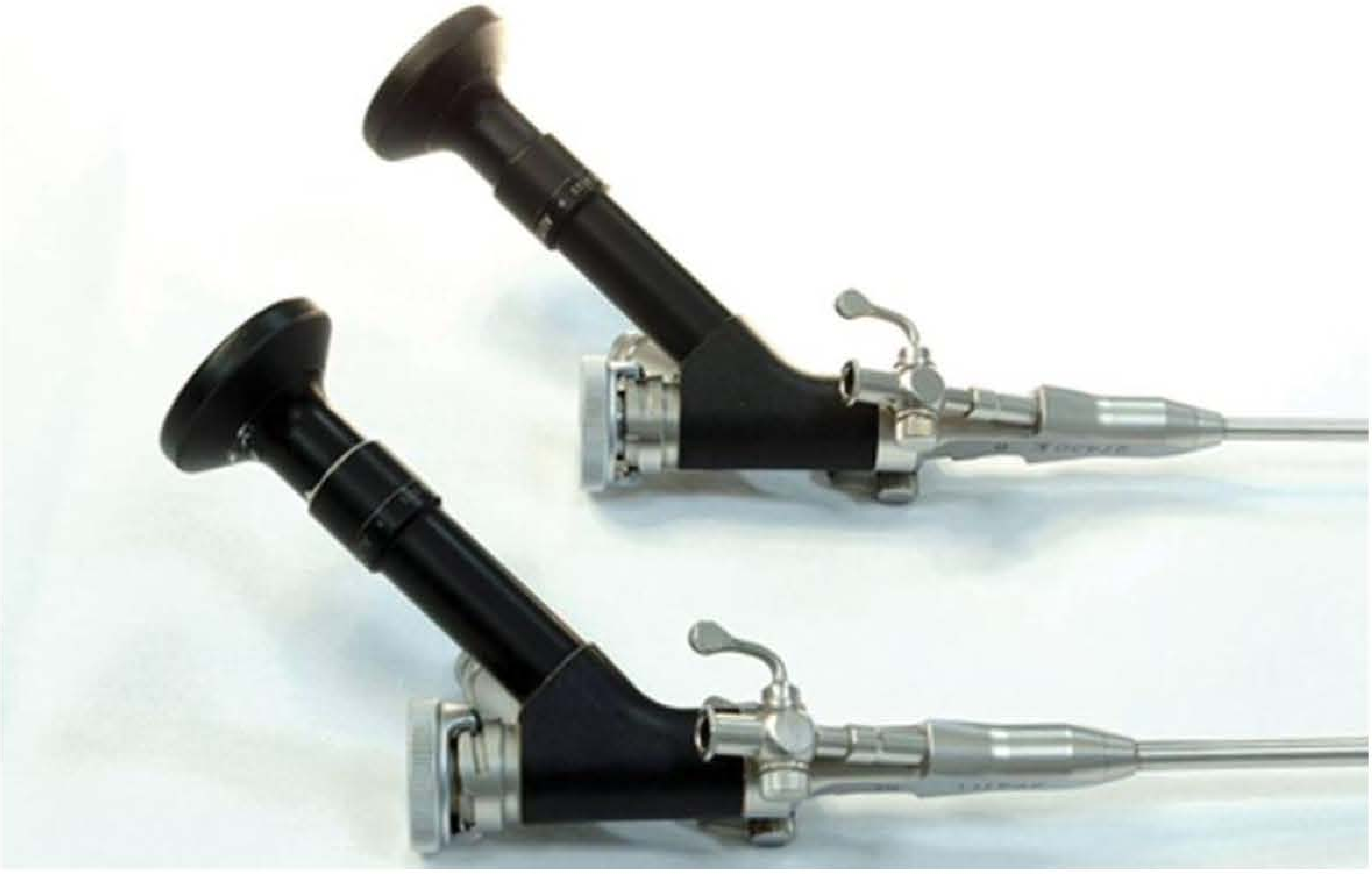

Figure 3.8 **Semirigid ureteroscope models with a central working channel.**

3.4. Flexible ureteroscopes

Although the first flexible endoscope was mentioned by Victor Marshall (1964), flexible fibroscopes have been introduced relatively recently into current urological practice.

These ureteroscopes have a similar structure to other types of flexible endoscopes: deflection mechanism, working channel, noncoherent fiber optic fascicle(s) for transmission of light, and a coherent fascicle of optic fibers for image transmission (Fig. 3.9).

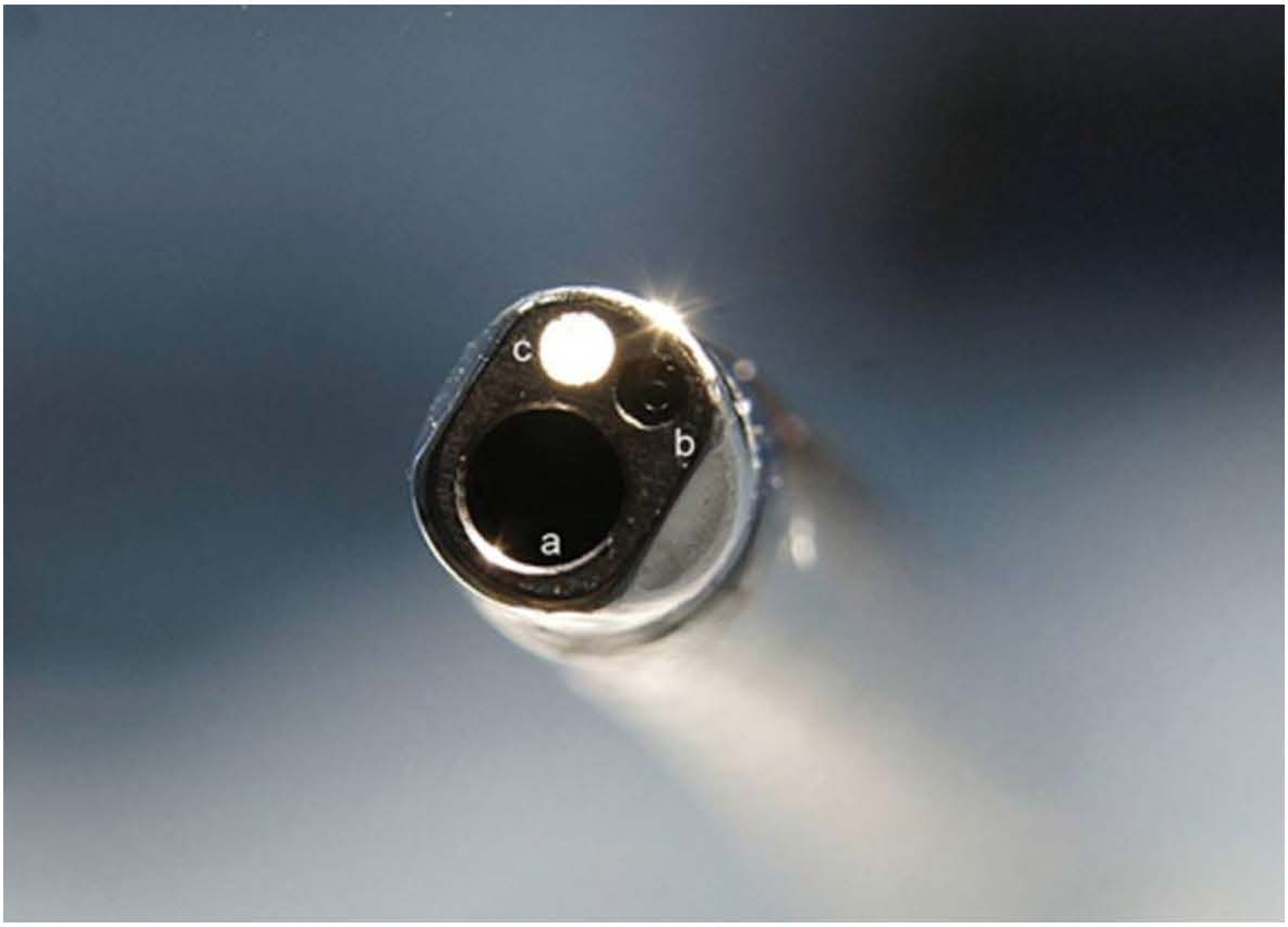

Figure 3.9 **External configuration of the distal end of the flexible ureteroscope.**
(a) Working channel, (b) fiber optic fascicle for image transmission, and (c) noncoherent optic fiber fascicle for transmission of light.

3.4.1. External Configuration

The distal part of flexible ureteroscopes is usually conical, with a smooth surface. Some ureteroscopes have a beveled, triangular end, facilitating the approach of the ureteral orifice and reducing the risk of parietal lesions.

3.4.2. Deflection Mechanism

The first flexible ureteroscopes did not have active deflection capabilities, their deformation being achieved only passively, due to the external sheath's elasticity. These mechanical properties only allowed the visualization of certain areas of the upper urinary tract, also accessible in most cases by rigid and semirigid ureteroscopes. Therefore, adding active deflection (Fig. 3.10) came as a natural addition, within the efforts to provide the new generation of flexible ureteroscopes with a superior maneuverability inside the upper urinary tract.

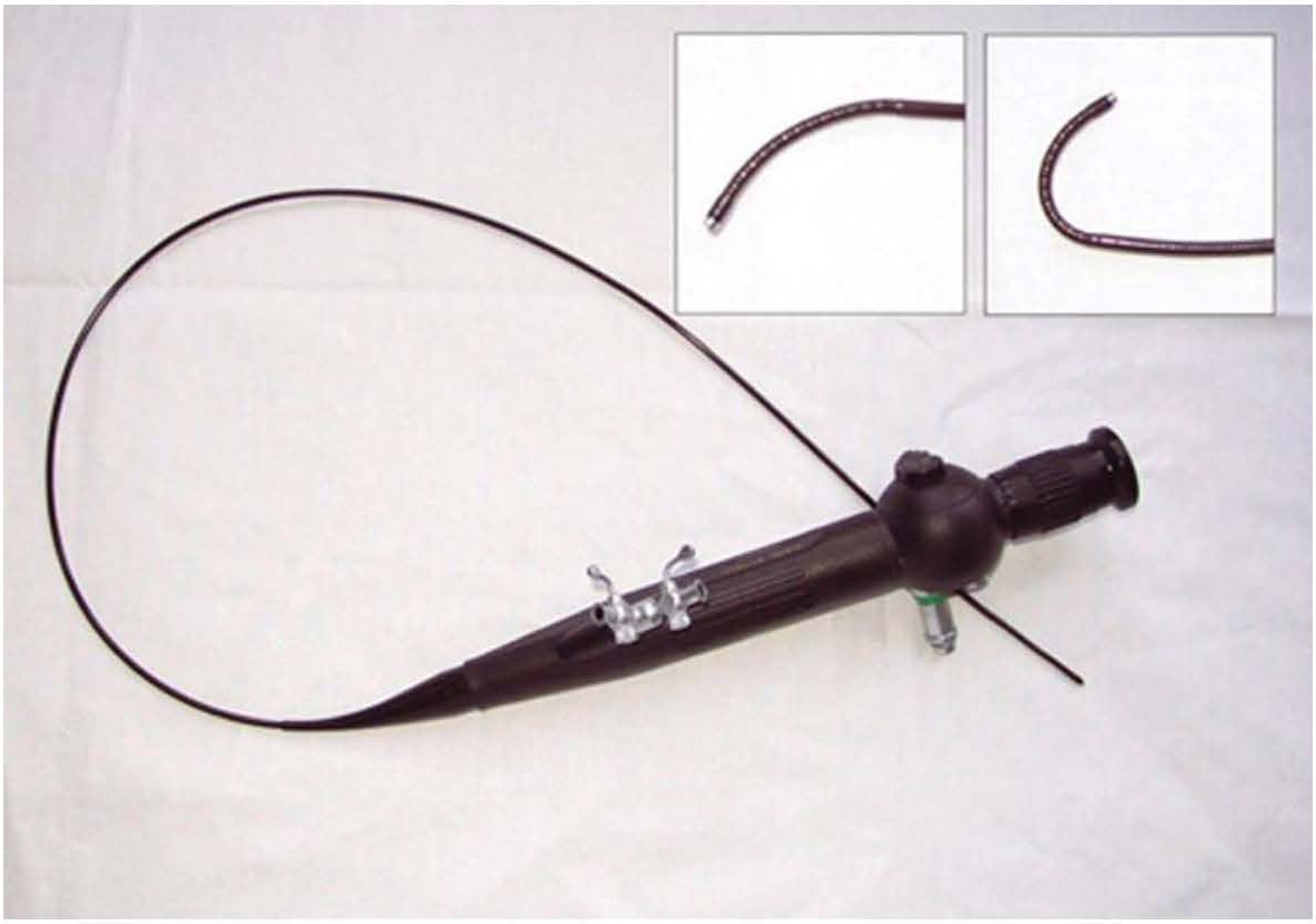

Figure 3.10 **Storz 11274AA flexible ureteroscope (Karl Storz Endoscopy, Tuttlingen, Germany) with a bidirectional active deflection.**

Active deflection is obtained by handling a mobile piece located on the ureteroscope's body with the thumb. Pushing it upward or downward (Fig. 3.11) determines the tensioning of metal fibers that stretch along the entire working segment of the ureteroscope, achieving bidirectional deflection of the distal end.

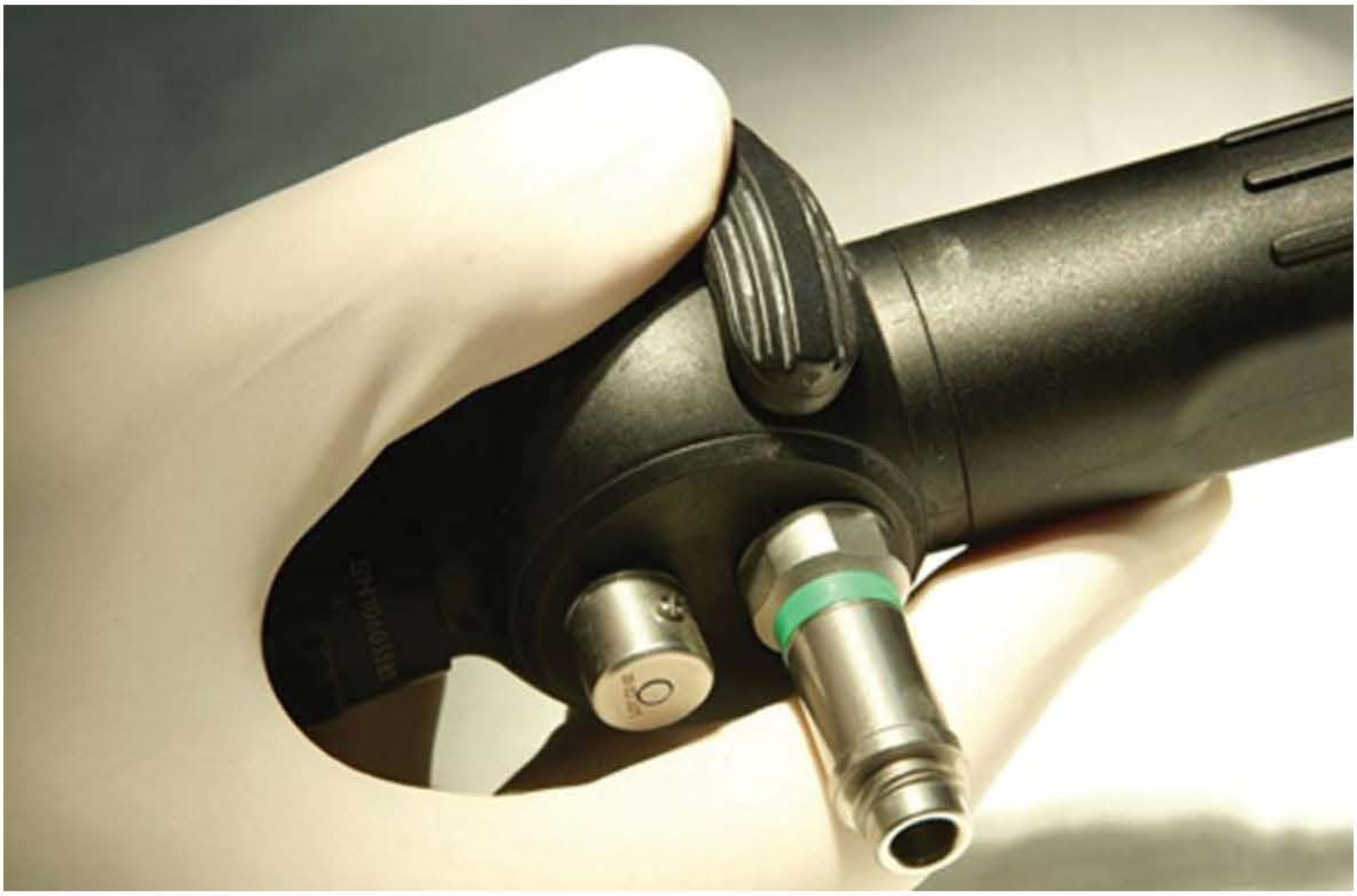

Figure 3.11 **The device for adjusting active deflection.**

This can be achieved in the direction of the pushing motion (an “intuitive” or “logical” deflection type, found in most American models), or against the direction of action (“counterintuitive,” “inversed logical,” or “international” deflection type, found in most European or Japanese models).

Modern flexible ureteroscopes have at least one area of active deflection, usually bidirectional. The high flexibility of the outer sheath in the distal segment allows for the appearance of a secondary, passive deflection area (Fig. 3.12).

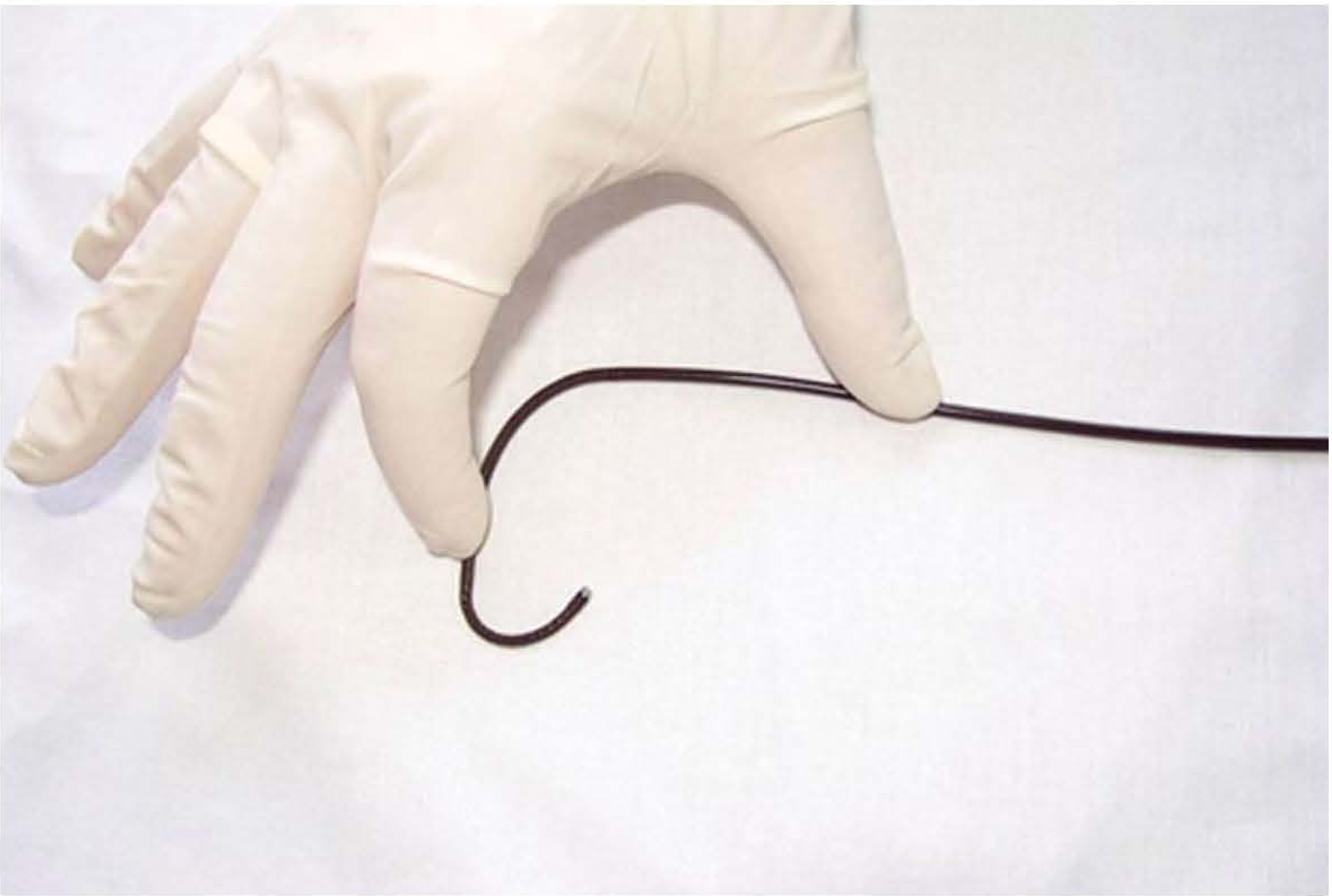

Figure 3.12 **The active primary and passive secondary deflection of the flexible ureteroscope.**

This is achieved by pushing the distal segment of the ureteroscope against the superior wall of the renal pelvis or against the implantation area of the middle or upper calyx in the pyelon, reason for which it can be limited by certain anatomic particularities or by the presence of certain pathological modifications (e.g., high-grade hydronephrosis).

The difficulties that arise during the attempts to approach certain areas of the pyelocaliceal system (especially the lower calyx) have required the upgrade of the active deflection system. A first concept was to create models with two active deflection segments that had superior maneuverability and were able to approach lesions that are sometimes inaccessible to the single deflection models (Ankem et al., 2004).

The first flexible ureteroscope to have these features was the ACMI DUR-8 Elite model (ACMI Corporation, Southborough, MA, USA) (Fig. 3.13) that, in addition to the 170°/180° upward/downward deflection of the DUR-8 model, allowed it to obtain an additional secondary active downward deflection of 130°. The secondary deflection is achieved by actioning a second mobile piece placed on the opposite side of the flexible ureteroscope's body.

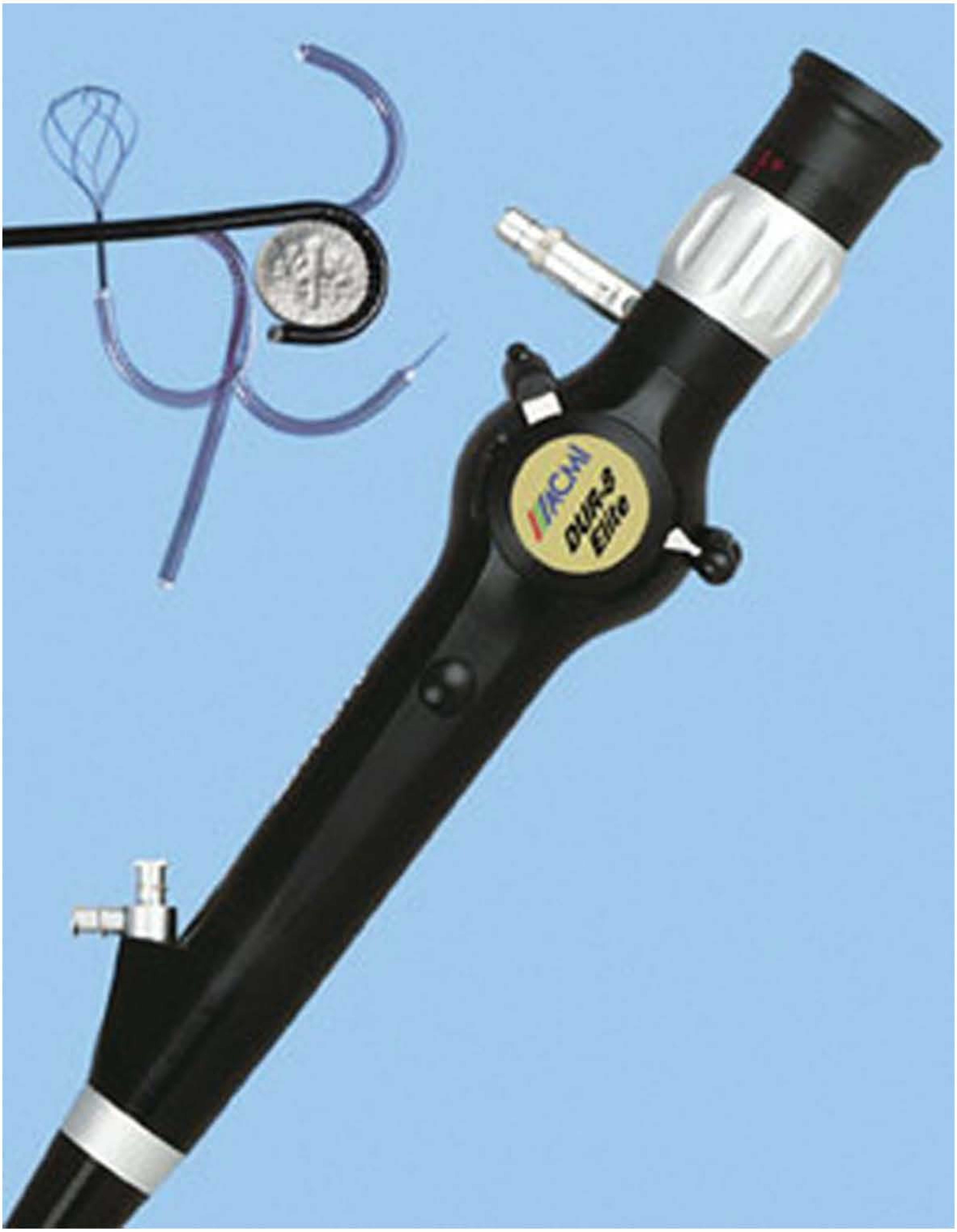

Figure 3.13 **Device for adjusting the active deflection.**

The Karl Storz Company (Karl Storz Endoscopy, Tuttlingen, Germany) adopted a different concept for improving maneuverability. In the Storz Flex-X (11278AU1) (Fig. 3.14) and Storz Flex-X2 models, the amplitude of the active deflection was increased (to 270° in both directions), as was its radius (the so-called “exaggerated deflection”) (Fig. 3.15).

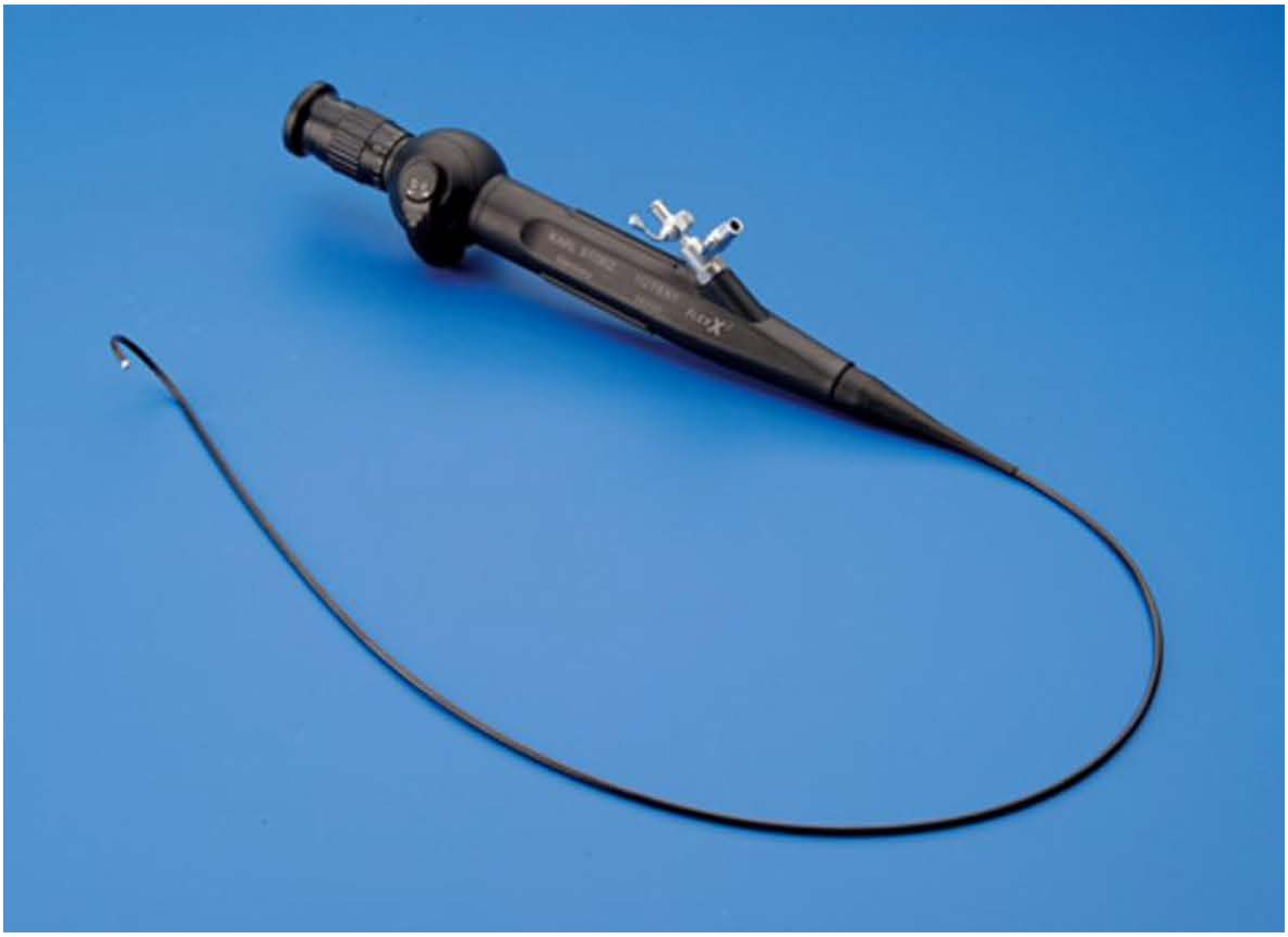

Figure 3.14 Storz Flex-X flexible ureteroscope (Karl Storz Endoscopy, Tuttlingen, Germany).

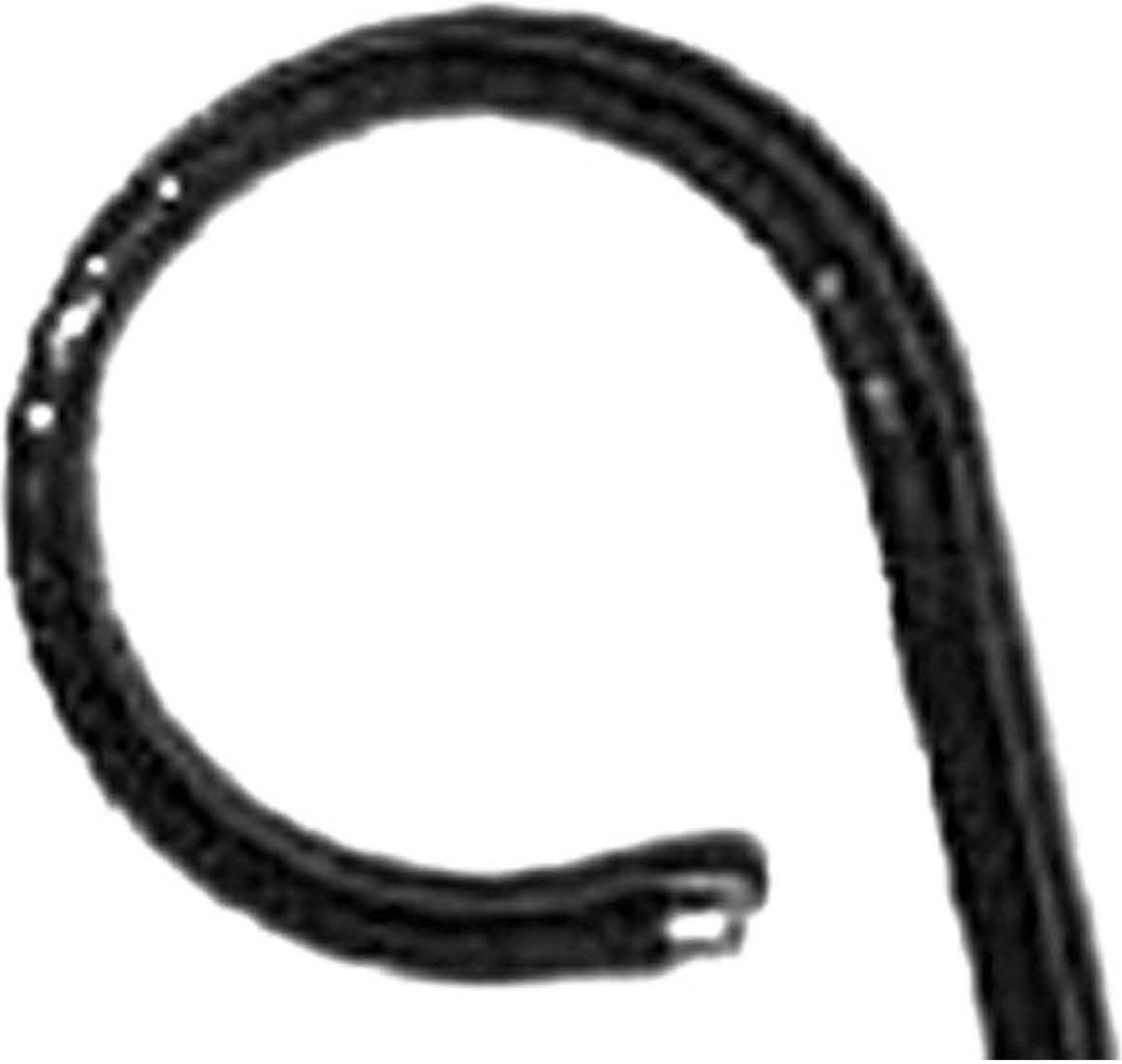

Figure 3.15 A 270° active deflection of the Storz Flex-X flexible ureteroscope.

Similarly, the new models of flexible ureteroscopes from Olympus (Olympus, Melville, NY, USA) and Richard Wolf (Richard Wolf, Knittlingen, Germany) offer amplitudes of the active deflection of over 270°.

3.4.3. Optical and Light Transmission Systems

In conventional flexible ureteroscopes, the transmission of light and images is achieved through optic fiber fascicles. These are glass fibers of approximately 8 µm, having a central part with a higher refraction index than the individual coating. Due to this property (Fig. 3.16), transmission of light becomes possible, even when the fibers are bent, a phenomenon called total internal reflection (Hecht, 2002).

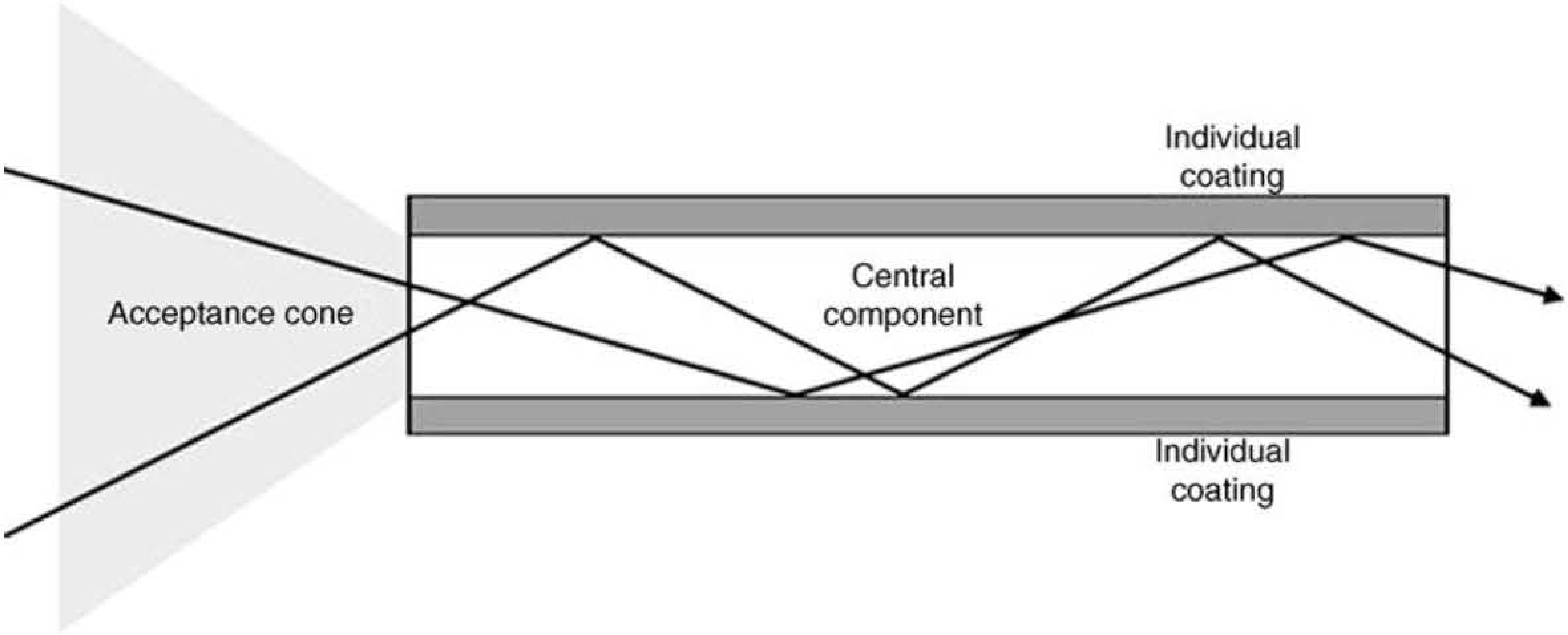

Figure 3.16 **The internal reflection phenomenon inside an optic fiber.**

If it is intended for the transmission of images, in order for them to be real, the optic fiber fascicle must have a coherent structure, with an identical disposition of the fibers at both ends. The resulting image is composed of the small images that are transmitted through each optic fiber.

Due to the fact that light is not transmitted through the individual coating, the final composed image will present a "honeycomb" effect (also named the "moiré" effect) (Figs 3.17 and 3.18). The use of special filters eliminates this effect, but with the cost of further lowering the image quality.

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2004;31:15–20.

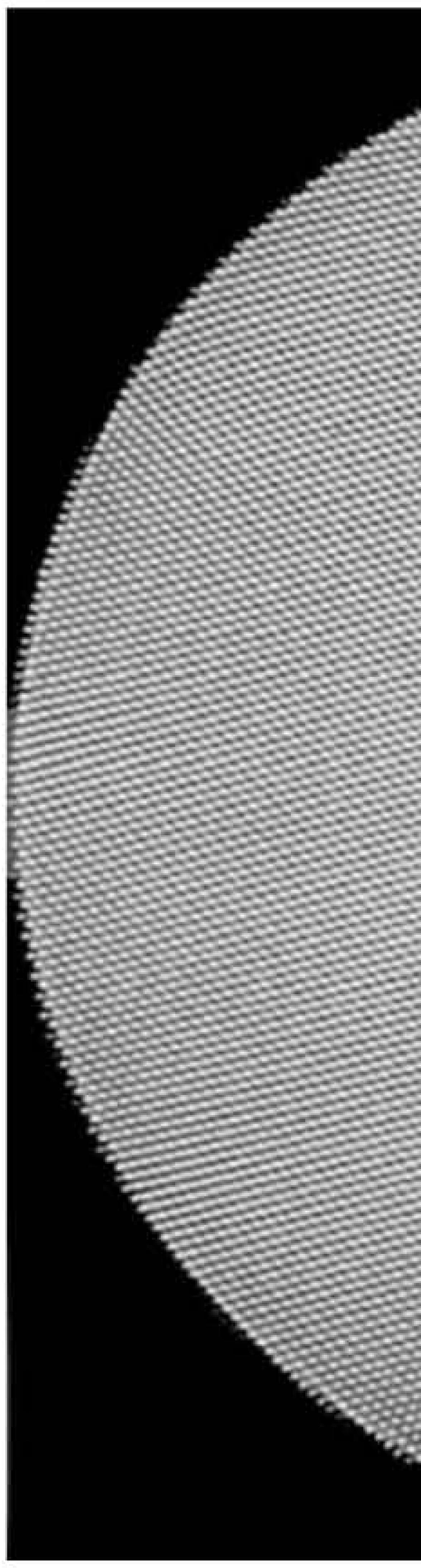

Figure 3.17 The “honey

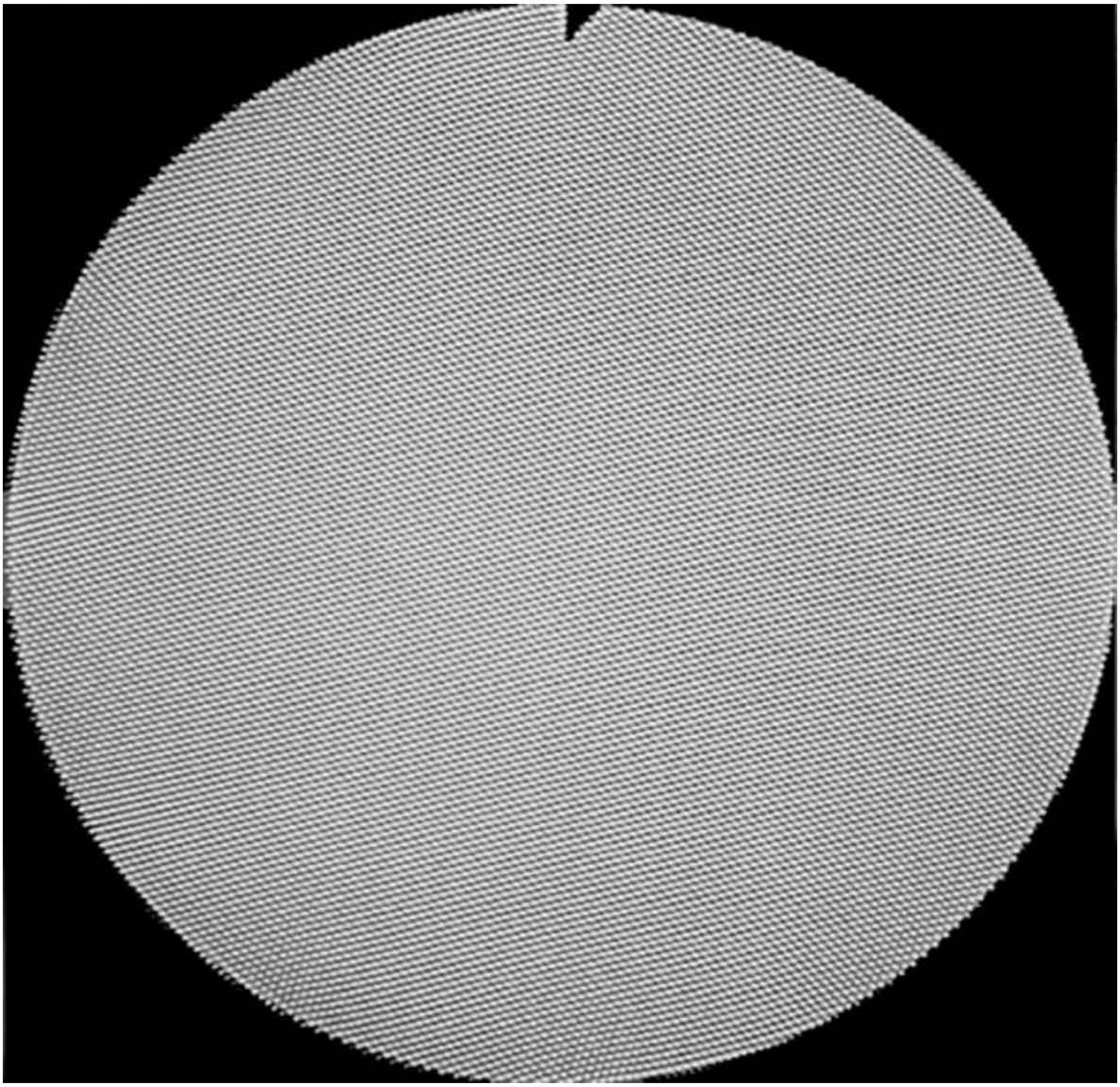

Figure 3.17 The “honeycomb” effect that is characteristic to the optical systems of conventional flexible endoscopes.

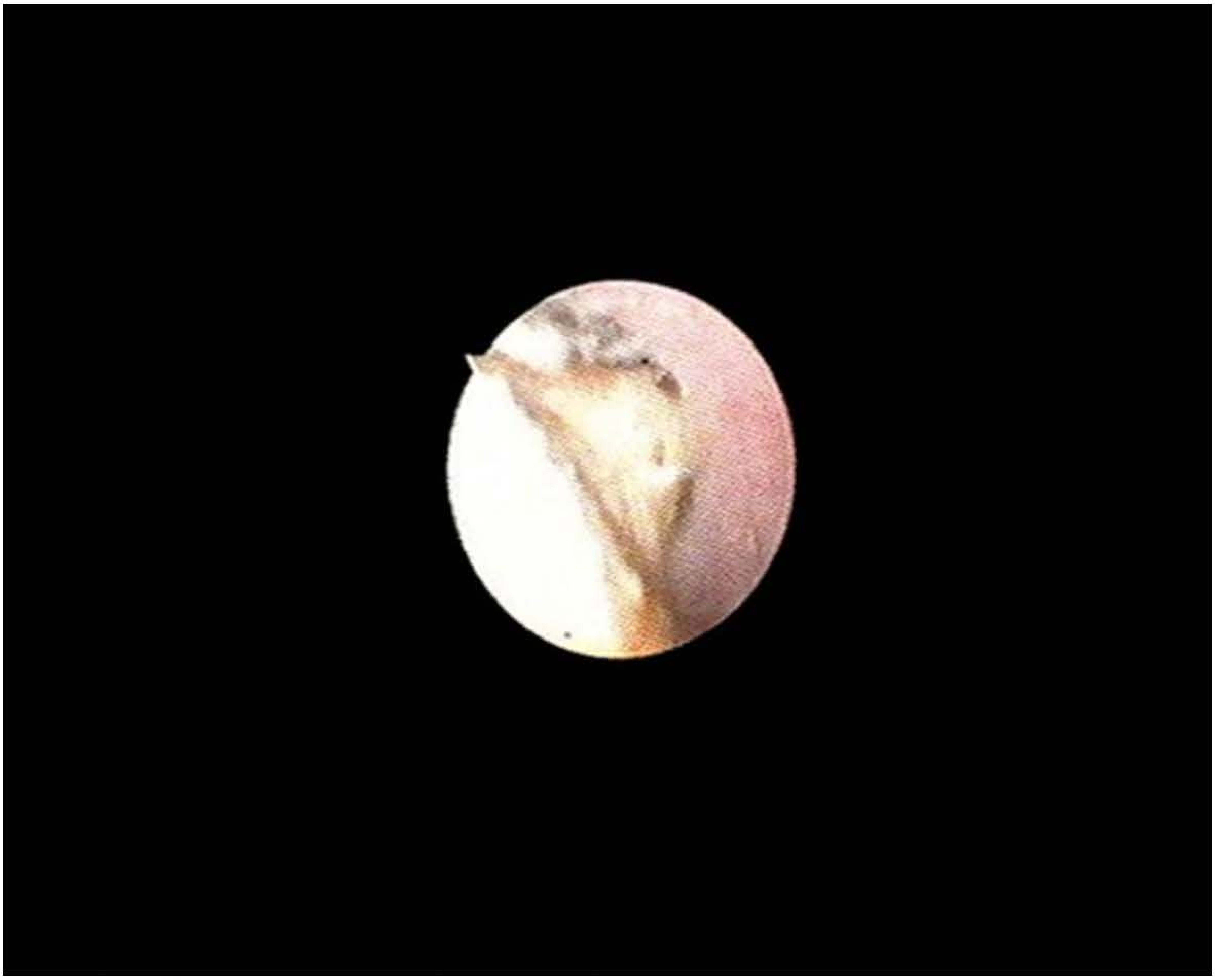

Figure 3.18 **Intraoperative flexible ureteroscopic image having a “honeycomb” effect.**

The resolution is directly proportional to the number of optical fibers in the fascicles. Modern technology has allowed packing a greater number of fibers into bundles, thus increasing the quality of the images.

Despite these technological advances, the images transmitted through the optic fiber systems of flexible ureteroscopes continue to have a lower resolution compared to those transmitted through the optical systems of rigid and semirigid ureteroscopes. The images, however, are sufficient enough to carry out the endoscopic procedures in good conditions.

For the transmission of light, the coherent disposition of the bundle’s fibers is not required. The number of these noncoherent fascicles varies according to the model.

The field of view of flexible ureteroscopes varies between 60° and 90°. A narrow field of view may be compensated for by using active deflection. For most instruments the viewing angle is 0°. Some models have a 90° angle that allows for a better visibility of the working instruments (Higashihara et al., 1990).

In the latest generation of flexible ureteroscopes, the conventional image transmission system has been replaced with a digital one. The ACMI DUR-D model, launched in September 2006, presents a CMOS-type digital sensor at its distal end. This receives the information and transmits it in digital format, through a single wire, to a processor that decodes it and projects it on the monitor. In addition, the noncoherent optic fiber fascicles used for the transmission of light have been replaced with a white light LED located at the distal end. Subsequently, other models of such flexible videoscopes were launched: the Olympus URF-Vo (Olympus, Melville, NY, USA) (Figs 3.19 and 3.20) and the Storz Flex-XC (Karl Storz Endoscopy, Tuttlingen, Germany) (Fig. 3.21).

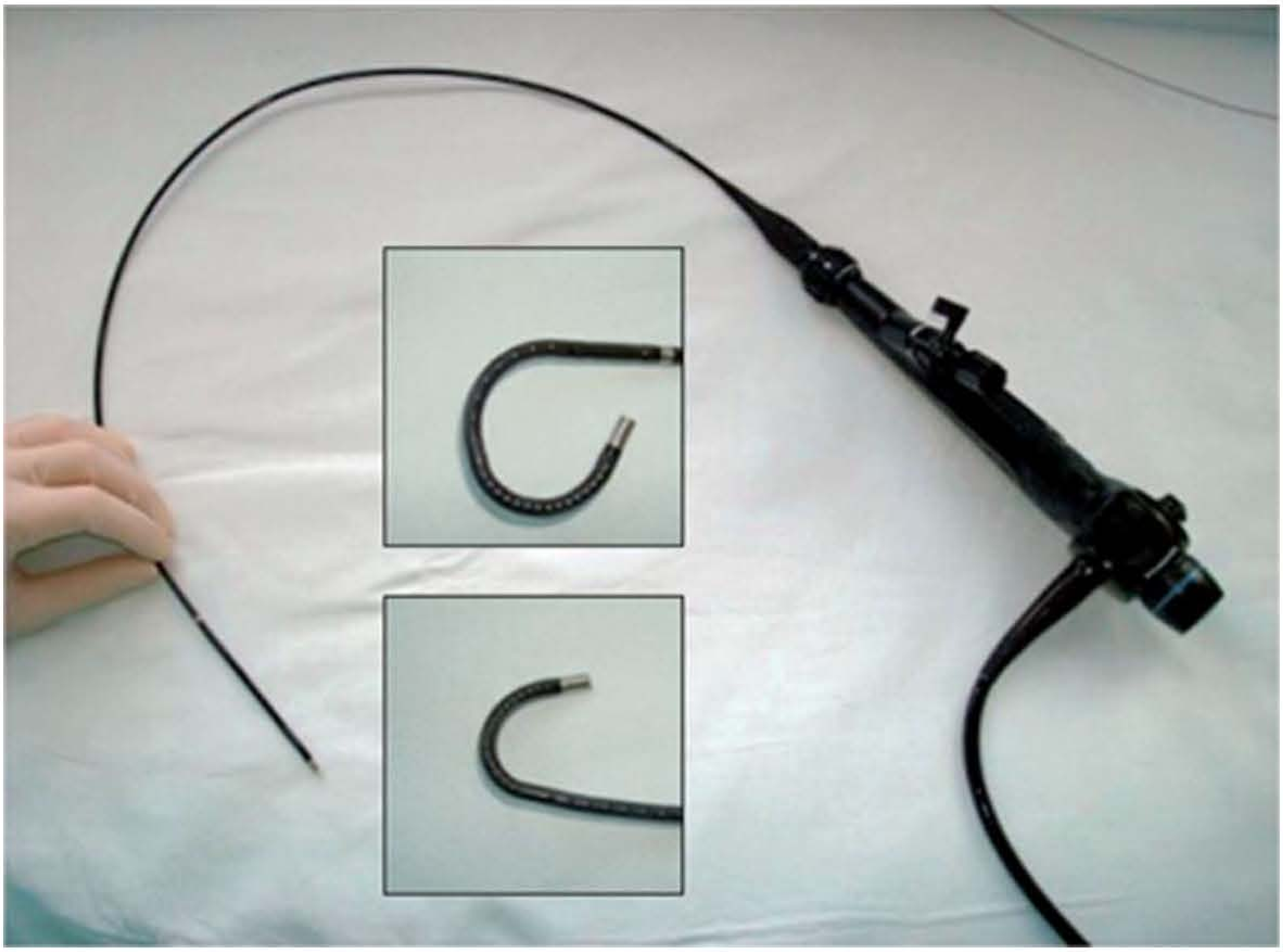

Figure 3.19 **Olympus URF-Vo digital flexible ureteroscope, with a 180°/270° deflection.**

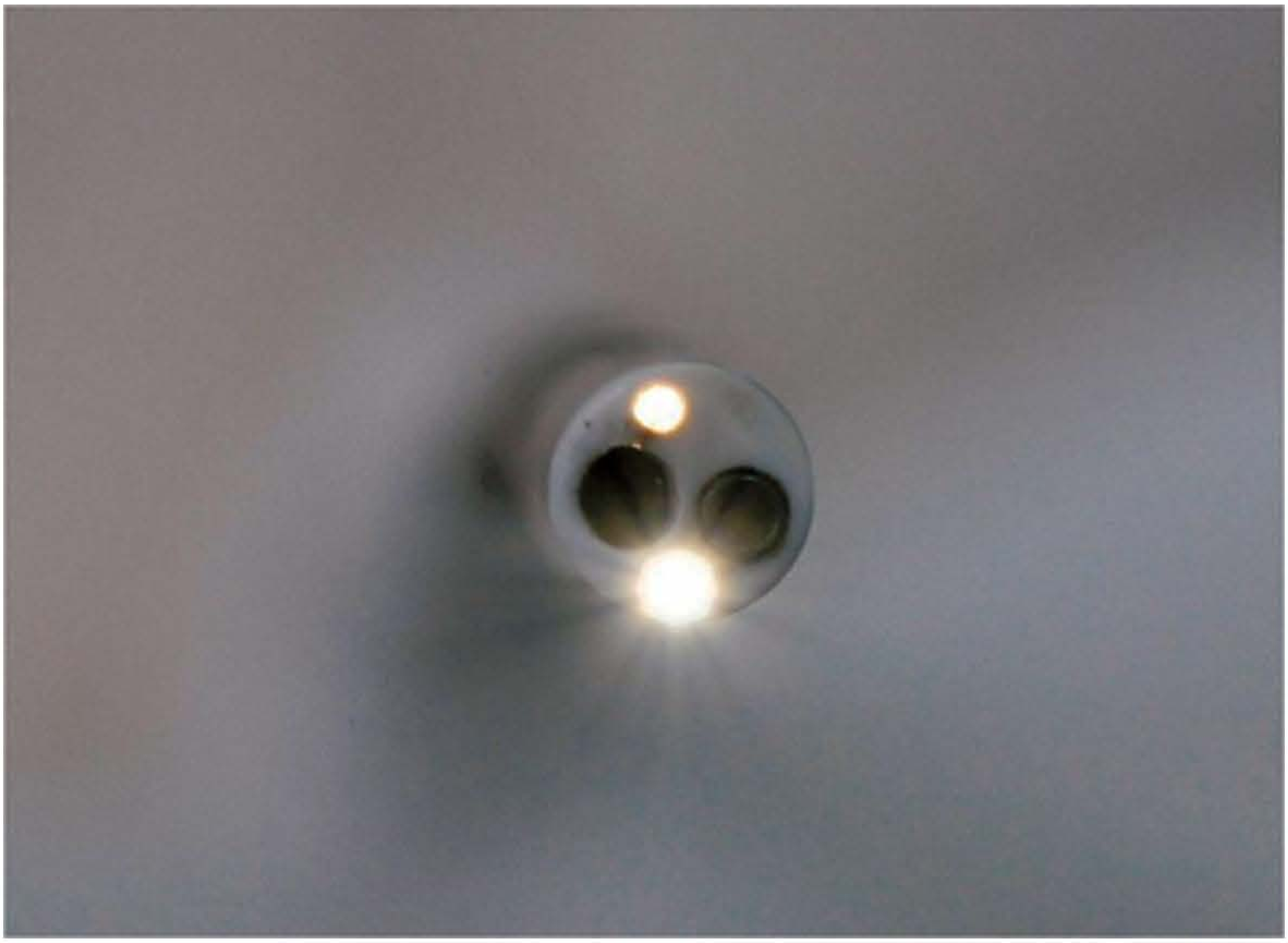

Figure 3.20 The distal end of the Olympus URF-Vo digital flexible ureteroscope (Olympus, Melville, NY, USA).

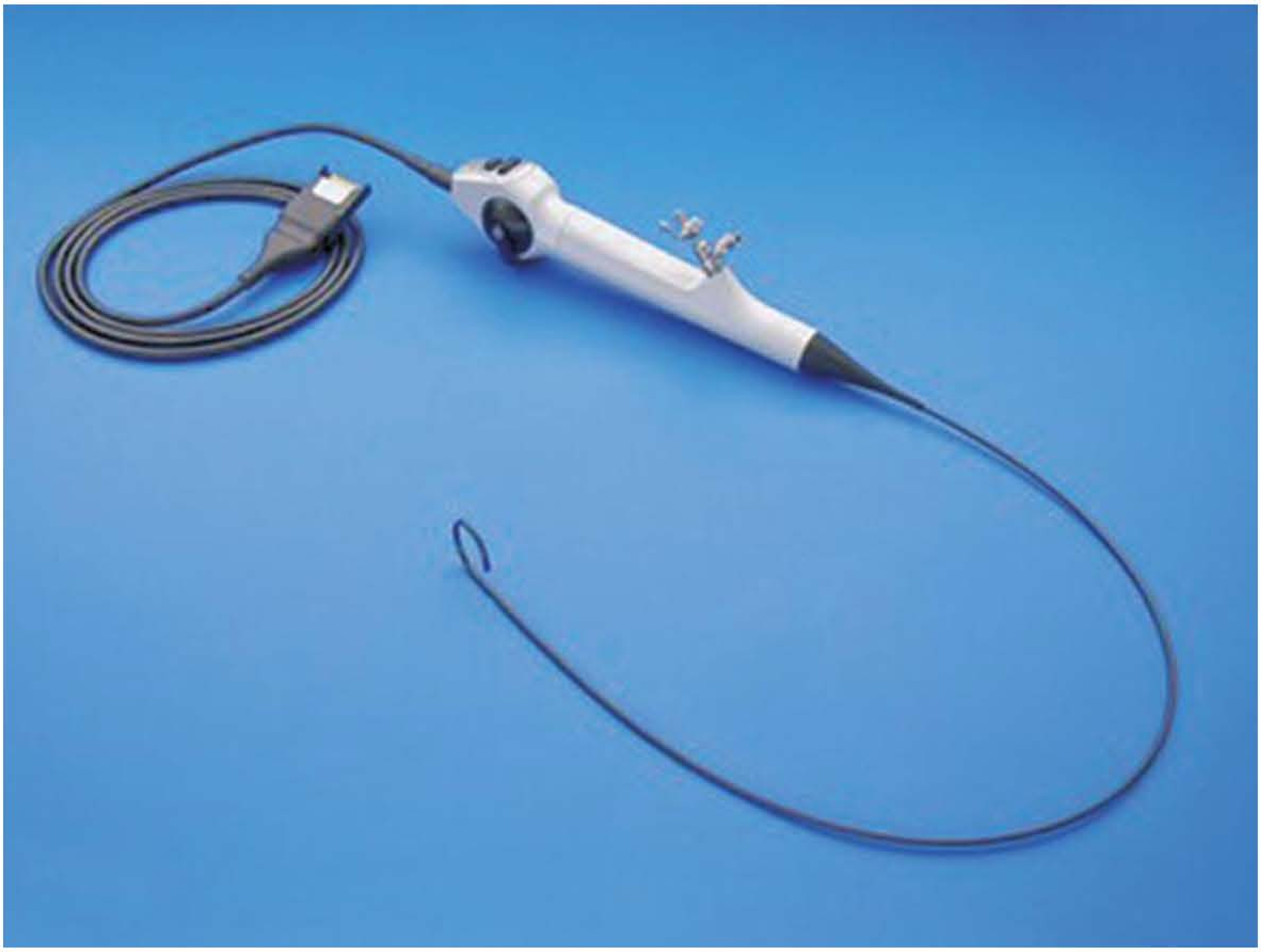

Figure 3.21 Storz Flex-XC digital flexible ureteroscope (Karl Storz Endoscopy, Tuttlingen, Germany).

The new generation of digital flexible ureteroscopes promises a superior flexibility and a much better visibility due to the replacement of the conventional optical system with all its inconveniences. Also, by removing these fragile components, the premises for a superior durability of the new endoscopes are created.

3.4.4. Working Channel

The working channel ensures the circulation of the irrigation fluid and allows the insertion of the accessory instruments and the probes or fibers of the energy sources for lithotripsy. Logically, the irrigation flow will be lowered directly proportional to the dimension of the accessory instruments or of the fibers that are inserted.

Most models of flexible ureteroscopes that are currently used have a 3.6 F working channel (Table 3.1). An exception is represented by the Wolf 7330.072 model that has a 4.5 F working channel, in the conditions in which the diameter of the endoscope's tip is of 9 F.

Table 3.1

Technical Characteristics of Some Models of Conventional Flexible Ureteroscopes

Manufacturing company	**Storz**	**ACMI**	**ACMI**	**ACMI**	**Wolf**	**Mitsubishi**	**Olympus**
Model	11274AA	AUR-7	DUR-8	DUR-8 Elite	7330.072 9 F	971101	URF-3
Diameter (F)							
Distal end	7.5	7.2	6.75	8.7	6	7.9	6.9

Sheath (maximum)	8.7	11	8.7	10.1	9	7.9	8.4
Working length (mm)	700	650	650	640	600	NA	700
Optics							
Visual field (degrees)	90	80 ± 5	80	80 ± 5	60	70	90
Visual angle (degrees)	0	9	9	9	0	0	0
Image dimension (cm²)	20.4	22	22	22	22	–	25
Optical fibers	Standard	Standard	Standard	Standard	Quartz	Quartz	Standard
Pixels/fiber	3000	–	3400	3400	5000	6000	5500
Working channel	3.6	3.6	3.6	3.6	4	3.6	3.6
Deflection mechanism							
Amplitude (degrees)	170/120	120/160	170/180	300/310	160/130	134/170	180/180
International	Yes	No	No[*]	No[*]	Yes	Yes	Yes
Secondary deflection	Passive	Passive	Passive	Active (130° downward)	Passive	Passive	Passive

After Parkin et al. (2002).

[*] The ACMI DUR-8 BA and DUR-8 Elite BA models have an international type deflection.

The Wolf Viper model (Richard Wolf, Knittlingen, Germany) has two separate working channels, so that the insertion of the accessory instruments no longer influences the flow of the irrigation fluid.

3.4.5. Future Perspectives

Solving the visibility and, partially, the reliability problems with the development of the digital flexible ureteroscopes were also unable to resolve the maneuverability and accessibility issues.

Minimization of the chips from the tip with the implicit reduction of the ureteroscope's dimensions is still a problem under evaluation. Reducing the influence of the accessory instruments on irrigation and deflection is also a direction of research.

An instrument that approaches the entire problem in a different manner is the Polyscope (Lumenis, Yokneam, Israel). This is an 8 F modular, maneuverable flexible ureteroscope, with a separate optical system with a 10,000 pixel resolution and a length of 1500 mm. The optical system is inserted through a single-use multilumen catheter. This configuration ensures, according to the authors, a better cost-efficiency ratio and a lower risk of damaging the optical system during its use. However, the new device is still awaiting validation in current clinical practice (Table 3.2).

Table 3.2

Technical Characteristics of Some Models of Digital Flexible Ureteroscopes

Manufacturing company	**Olympus**	**Storz**	**ACMI**
Model	URF-Vo	Flex-XC	DUR-D
Diameter (F)			
Distal end	8.5	8.5	8.7
Sheath (maximum)	9.9	8.5	9.3
Working length (mm)	670	700	650
Optics			
Visual field (degrees)	90	90	80
Visual angle (degrees)	0	0	0
Working channel	3.6	3.6	3.6

Deflection mechanism			
Amplitude (degrees)	180/275	270/270	250/250
International	Yes	Yes	Yes

3.5. Energy sources

3.5.1. Ballistic Lithotripsy

Ballistic lithotripsy represents a stone destruction method in which the pulsatile compression produced by air or electromechanic forces is transmitted through a metallic rod. The first ballistic lithotriptor was represented by the Swiss lithoclast, introduced into practice at the beginning of the 1990s. The pulsations produced using compressed air lead to the movement of a metallic sphere that induces impulses of the probe with a frequency of 12 cycles/s, determining the repeated contact between the probe and the stone (Denstedt et al., 1991). Subsequently, the electrokinetic lithotriptor was developed (Fig. 3.22), which works by creating an electromagnetic field that determines vibrations of the probe with a frequency of 15–30 cycles/s. Comparative studies regarding the efficiency of the two types of ballistic lithotripsy have shown similar results with regard to stone fragmentation, as well as equivalent rates of proximal migration of the fragments and of complications (Vorreuther et al., 1998; Menezes et al., 2000).

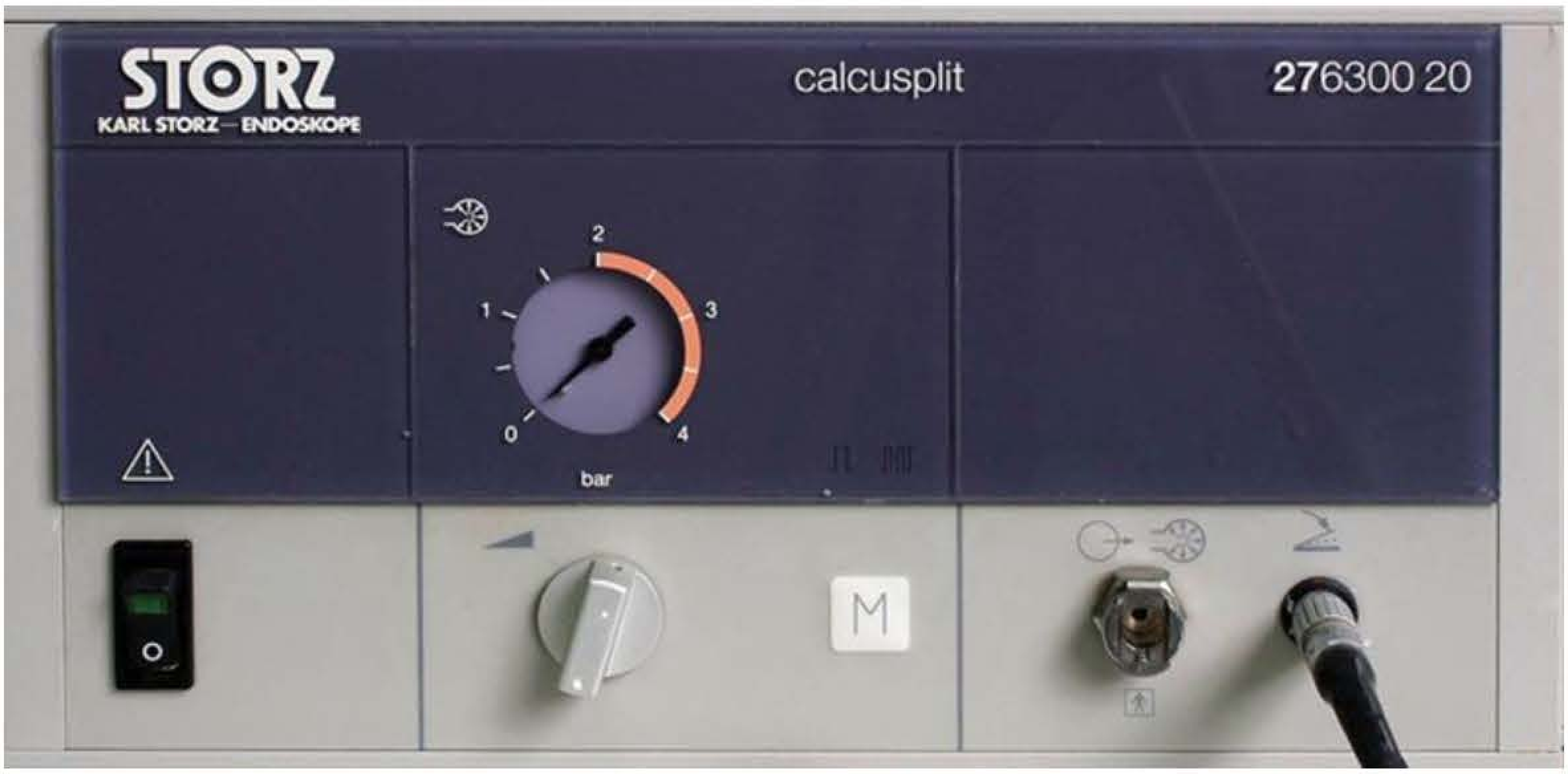

Figure 3.22 **Electrokinetic-type energy source for ballistic lithotripsy.**

The probes used by the ballistic lithotriptor may have a diameter between 2.4 F and 6 F, and can be used for semirigid or rigid ureteroscopy. Compared to the electrohydraulic, ultrasonic, or laser lithotripsy, ballistic lithotripsy has a lower risk of ureteral perforations (Piergiovanni et al., 1994), the mean rate of occurrence for this complication being lower than 1% across different studies (Vorreuther et al., 1998; Menezes et al., 2000).

Another advantage of ballistic lithotripsy is represented by the relatively low costs and the easy maintenance of the equipment (Hofbauer et al., 1995).

The disadvantages of ballistic lithotripsy are determined by the rigidity of the probes, which does not allow their use during flexible ureteroscopy. Also, ballistic lithotripsy is associated with a rate of ascendent stone migration varying between 2% and 17%.

Recently, ballistic lithotriptors have been improved by attaching a suction pump that facilitates the evacuation of fragments (Delvecchio et al., 2000) and by using nitinol probes that allow their use during flexible ureteroscopy (Tawfiek et al., 1997).

Data regarding the benefits of associating aspiration during lithotripsy for preventing ascendent migration are limited (Knispel et al., 1998; Delvecchio et al., 2000).

3.5.2. Ultrasonic Lithotripsy

Ultrasonic lithotripsy (Fig. 3.23) is a safe and efficient procedure that achieves a controlled stone destruction and allows for the rapid evacuation of the resulted fragments under endoscopic control.

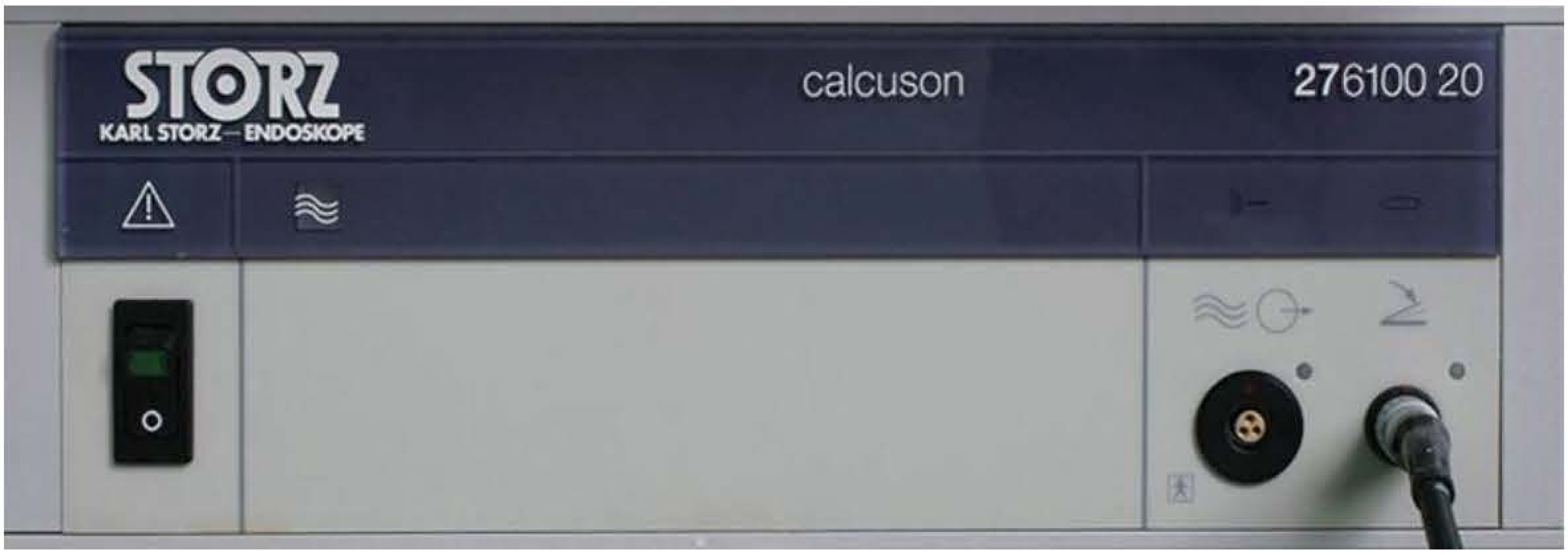

Figure 3.23 **Energy source for ultrasonic lithotripsy.**

The idea of using ultrasounds in lithotripsy belongs to Mulvaney (1953). The attempt to fragment the stones using sound waves with a frequency of 0.8 kHz failed. In 1955, Coates achieved *in vitro* lithotripsy, using 15 kHz sound waves. After 15 years, Trehorst is the first to fragment a bladder stone *in vivo* using ultrasounds. In 1979, Marberger and Alken, using energies of 23–25 kHz, introduced ultrasound lithotripsy in the percutaneous treatment of renal lithiasis.

The principle of this method consists of transforming electrical energy into ultrasonic energy. The electrical current produced by a generator is transmitted to the transducer, determining the excitation of a piezoelectric crystal. The crystal vibrates at a specific frequency, generating an acoustic wave with the frequency of 23–25 kHz. At the operating frequencies, high-pitch sounds can be heard, having different metallic tones that vary according to the amount of liquid that has been suctioned and to the pressure gradient exerted by the sonotrode on the stone. However, there is also a high level of sound, imperceptible to the human ear, that can reach an intensity of 98 dB (Segura and LeRoy, 1984).

The resultant ultrasonic waves are transmitted longitudinally through the sonotrode to the stone. In contact with the probe, the stone vibrates until it is fragmented. Placing the sonotrode in contact with the urothelium causes minimal lesions, due to the fact that the tissues do not resonate at the vibrating energy (Grocela and Dretler, 1997). Although heating of the probe's tip occurs during lithotripsy, at an irrigation flow of 30 mL/min, the rise in temperature is of maximum 1.4°C (Marberger, 1983). The flow of the irrigation fluid during ureteroscopy can be limited, and for this reason ultrasonic lithotripsy is recommended especially during percutaneous interventions. A suction pressure of 60–80 cm H_2O is sufficient to maintain a proper irrigation flow during lithotripsy. Higher suction pressures may lead to the emergence of air bubbles, with the consecutive impairment of visibility.

The lithotripsy probes have a diameter between 2.5 F and 12 F. The 2.5-F probes are not fitted with an irrigation channel because this can lead to heating. Bending of the probe determines a loss of energy at the convexity area, with the consecutive reduction of efficiency (Marberger, 1983; Denstedt, 1996).

The major advantage of ultrasonic lithotripsy is represented by the efficient combination between stone destruction and fragment removal. Those smaller than 2 mm are suctioned through the probe's channel along with the irrigation fluid, while larger fragments can be extracted with forceps or with the basket probe.

The rigidity and diameter of the probes limit the use of this technology in the treatment of ureteral stones. However, the success rate of ultrasonic lithotripsy reported in the literature varies between 69% and 100% (Denstedt, 1996). This technique may be used with good results for large ureteral stones and, in the case of the steinstrasse syndrome, for the easy extraction of fragments. Favorable results have also been reported for distal ureteral stones that can be approached with rigid ureteroscopes (Grocela and Dretler, 1997; Segura, 1999).

3.5.3. Electrohydraulic Lithotripsy

Electrohydraulic lithotripsy (Fig. 3.24) is an efficient and safe renal and ureteral lithotripsy method, but is used less frequently than the ultrasonic method. Taking into account the electrodes' flexibility, the largest field of application is represented by antegrade or retrograde flexible endoscopy.

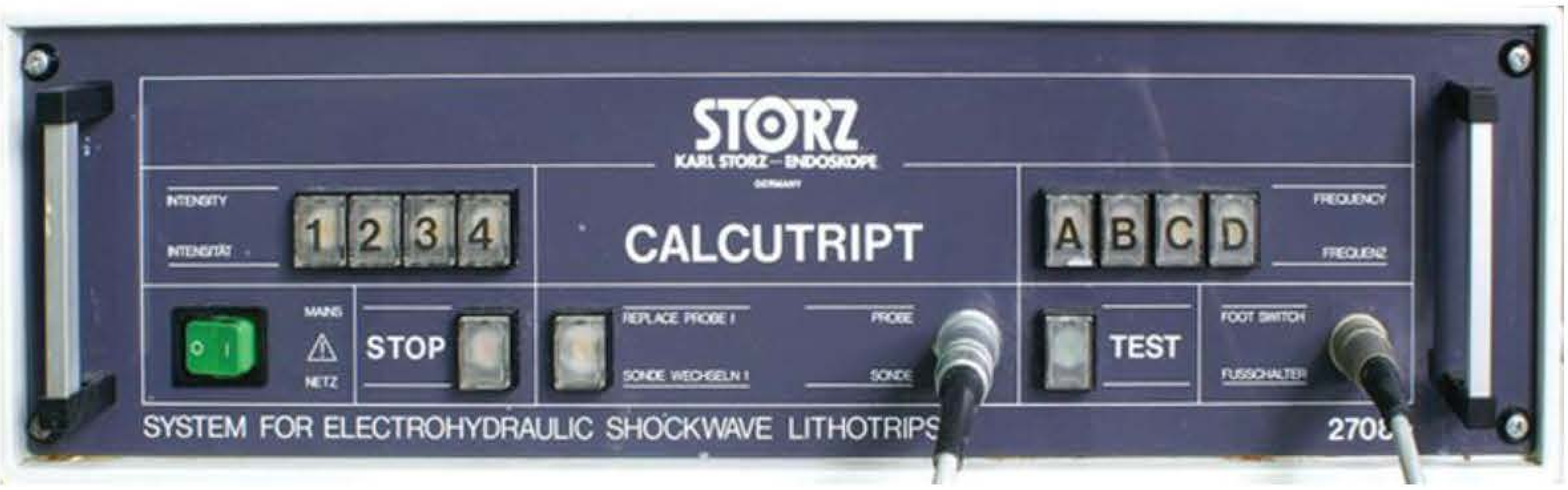
STORZ
KARL STORZ—ENDOSKOPE
GERMANY
INTENSITY
INTENSITÄT
1
2
3
4
CALCUTRIPT
A
B
C
D
FREQUENCY
FREQUENZ
MAINS
NETZ
STOP
REPLACE PROBE !
SONDE WECHSELN !
PROBE
SONDE
TEST
FOOT SWITCH
FUSSCHALTER
SYSTEM FOR ELECTROHYDRAULIC SHOCKWAVE LITHOTRIPS
2708

Figure 3.24 Energy source for electrohydraulic lithotripsy.

The first electrohydraulic lithotriptor, Urat-I (YPAT-1), was developed in 1955 by Yutkin, at the Kiev University, being initially used only in the Eastern European Bloc (Grocela and Dretler, 1997). In 1960, Rose and Goldberg used electrohydraulic lithotripsy to fragment bladder stones. The first clinical application of this type of lithotripsy for renal stones was performed during a pyelolithotomy by Raney and Handler (1975). Subsequently, Lawson, Clayman, and other authors successfully used the method for large renal stones.

In 1985, Lytton and coworkers reported the use of electrohydraulic lithotripsy in the ureteroscopic treatment of ureteral lithiasis, without early or late postoperative complications.

Although the first electrohydraulic probes had a large diameter (9 F), the diameter was reduced to 1.5–5 F as a result of technical advances.

Using small caliber probes (Fig. 3.25) allows for better irrigation. Different probe diameters have comparable efficiency, although the electric resistance of the larger probes is lower (Segura, 1999). Electrohydraulic lithotripsy was first used during flexible ureteroscopy by Begun et al. (1988).

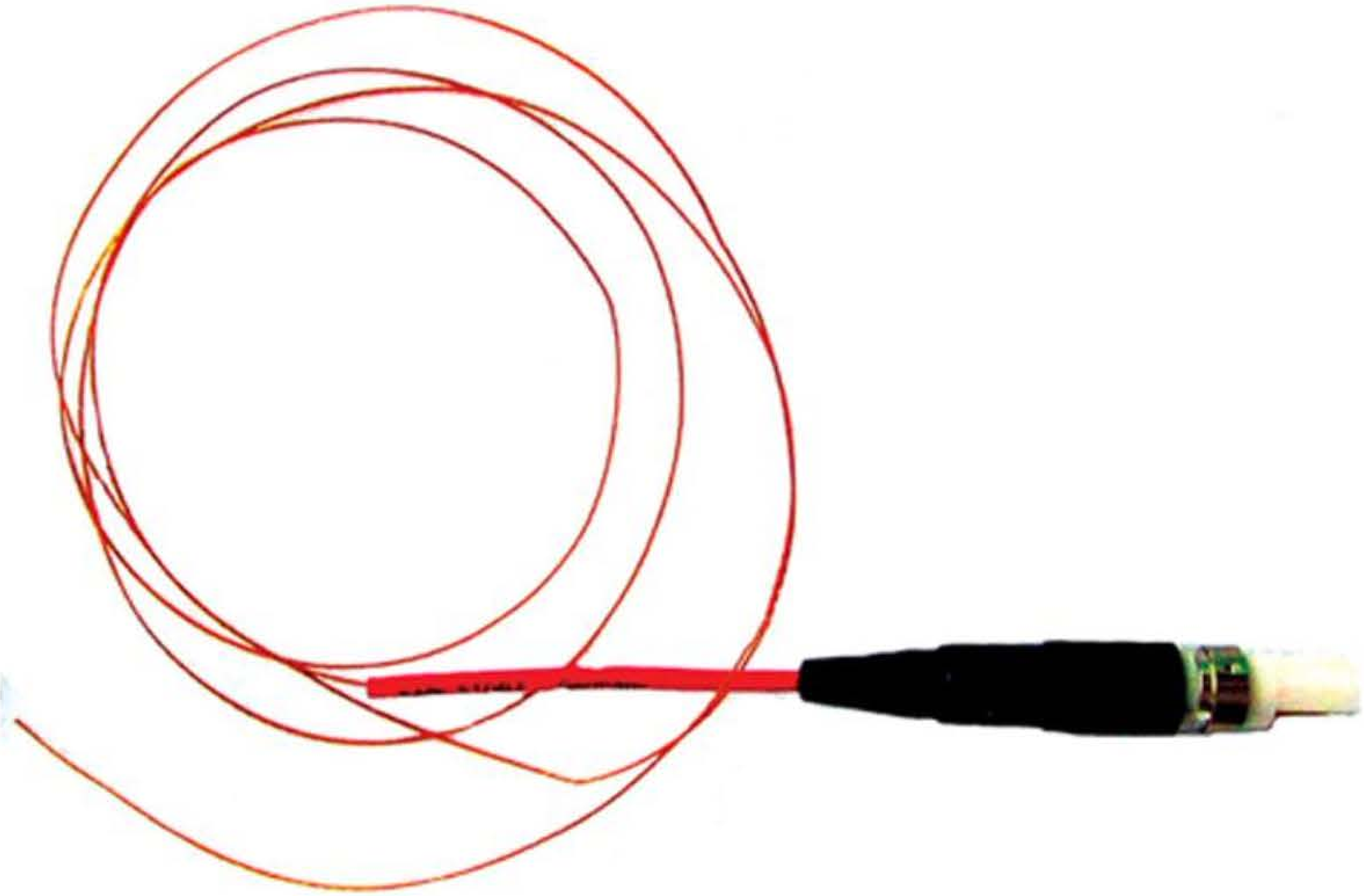

Figure 3.25 Electrohydraulic lithotripsy probe.

Electrohydraulic lithotripsy allows for stone fragmentation through shockwaves generated by an electrical discharge in a liquid medium. The probes consist of two coaxial electrodes, isolated from each other and from the external medium.

The electrical discharge between them generates a spark at the tip of the probe, releasing thermal energy that develops a large amount of caloric energy in a small space.

In the liquid medium, the intense heat determines the vaporization of a small quantity of the irrigation fluid. Due to the gas bubble formation at the tip of the probe, the liquid is pushed with force, hence resulting the hydraulic shockwaves. The impact of the shockwaves with the stone is sufficient to crack it. A second and third shockwave are produced indirectly, as a result of the first wave's recoil. These sequences are carried out with a rhythmicity of 1/800 per second, as long as the electrode is activated.

Depending on the distance between the lithotripsy probe and the stone's surface, the gas bubble may collapse in a symmetrical manner (if the distance is of approximately 1 mm), generating a powerful shockwave, or asymmetrically (if the distance is of approximately 3 mm), propelling a jet of liquid (Zhong et al., 1997).

Due to the risk of damaging the optical system, the electrohydraulic lithotripsy probe should be discharged at least 2–5 mm from the tip of the ureteroscope (Lingeman et al., 2002).

The amount of energy obtained by the electrical discharge at the tip of the probe depends on the voltage and capacitance. Vorreutger's experimental studies showed that the maximum pressure, as well as the speed with which this is obtained, depends only on the voltage, the capacitance influencing the persistence of the shockwave over time (Vorreuther and Engelking, 1992; Vorreuther and Engelmann, 1995). Therefore, through the variations of these two parameters, shockwaves with maximum pressure and with different degrees of persistence over time are obtained, although the influence of these patterns on the efficiency of the lithotripsy is still insufficiently assessed (Knudsen and Denstedt, 2007).

Although initially it was considered that the optimal irrigation fluid is represented by a 1/6–1/7 saline solution, electrohydraulic lithotripsy may also be performed using standard saline (Denstedt and Clayman, 1990). When using pure water as an irrigation fluid, the efficiency drops due to the generation of an inefficient spark. It is also important for the temperature of the irrigation fluid to be around 37°C.

The use of electrohydraulic lithotripsy comes with a series of advantages:

- reduced acquisition and usage costs in comparison with the other lithotriptors
- widely accessible method

Unfortunately, there are a series of disadvantages that limit the performances of the method:

- a higher aggression on the surrounding tissues and on the optical systems of the ureteroscopes
- the possibility of deteriorating the probes during use, with the need to remove the detached fragments (parts of the external isolating layer, distal metallic ends, etc.)
- single-use probes
- poorer results for the fragmentation of stones with certain chemical compositions

The major disadvantage of electrohydraulic lithotripsy is the need to maintain a safe distance in order to prevent mucosal lesions or ureteral perforation. In a study regarding the results of electrohydraulic lithotripsy using 9 F probes in the treatment of distal ureteral stones, Raney (1978) obtained a 90% success rate, but with an incidence of urinary leakage of 40%.

Despite the technical advances, ureteral perforation continues to represent a frequent complication. Hofbauer et al. (1995) reported, in a prospective study on a group of 72 patients, a 17.6% rate of perforations after electrohydraulic lithotripsy, in comparison with 2.6% for pneumatic lithotripsy. Vorreuther (1995) suggested that the mechanism of lesion occurrence consists in the expansion of bubbles, a phenomenon that takes place even if the probe does not come into direct contact with the ureteral mucosa. The diameter of the cavitation bubbles depends on the energy used and can exceed 1.5 cm in instances of energies higher than 1300 mJ. For this reason, the risk of perforations is increased in case of rough stones, which require high energy levels. Even in the case of small caliber probes, perforation can occur if a high number of impulses is used close to the mucosa. In a comparative *in vitro* study, Santa-Cruz et al. (1998) observed that electrohydraulic lithotripsy is associated with a high rate of ureteral perforation, in comparison with pulsed laser or with ballistic lithotripsy. The risk of this complication increases in case of impacted stones with important edema or when the visibility is reduced due to bleeding secondary to the lithotripsy (Hofbauer et al., 1995).

Similar to the other lithotripsy methods, electrohydraulic fragmentation determines the retrograde propulsion of the fragments (Teichman et al., 1997). A disadvantage compared to the use of the Ho:YAG laser is represented by the dimensions of the resulted fragments, especially in case of stones larger than 15 mm.

The advantages of electrohydraulic lithotripsy include the flexibility of the probes (especially the ones with a low caliber of 1.6–1.9 F), which allows performing intracorporeal lithotripsy by rigid or flexible ureteroscopy.

For each case, an average number of 1–1.3 probes is required, with the exception of rough stones (calcium oxalate monohydrate) that can require more than two probes (Drach et al., 1986).

3.5.4. Lasers

A series of lasers, with different wavelengths, have application in urology (Fig. 3.26).

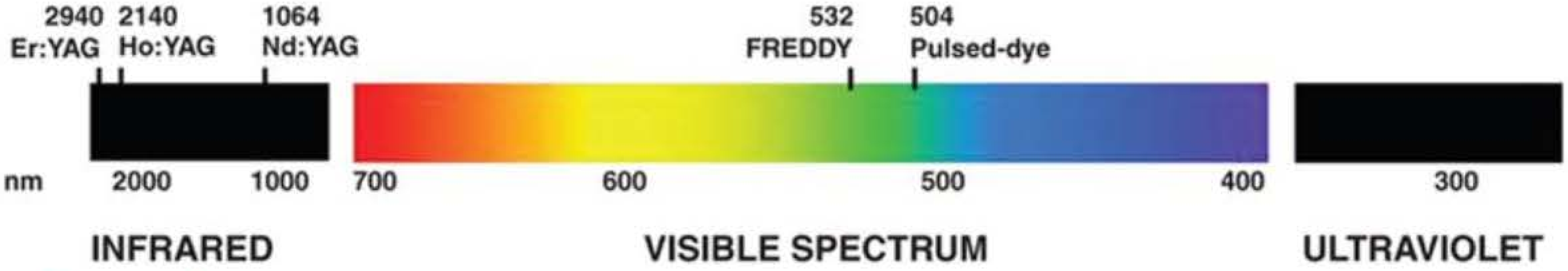

Figure 3.26 **Wavelengths of certain types of lasers with application in endourology and their position in the electromagnetic spectrum.**

The basic principle of laser technology (light amplification by stimulated emission of radiation) is represented by photon emission, produced by the stimulation of atoms by external energy sources. Due to this excitation, the electrons shift their orbit, their recovery to their initial state being achieved with emission of energy under the form of photons.

The laser was introduced into urological practice for the first time in 1968 by Mulvaney and Beck, who used a ruby laser to fragment stones (Mulvaney and Beck, 1968). This type of laser generates a continuous beam, with the emission of excessive heat, a fact that prevents its use in practice.

Lasers with pulsatile-type emission are currently used for lithotripsy. These lasers deliver energy in short bursts, therefore obtaining a high power without heating the application area, thus avoiding tissue damage. In theory, lasers with continuous-type emission, such as neodymium:YAG (Nd:YAG), could also be used for stone fragmentation, but the overheating of the application area produced by the emission of energy for a long period of time limits their use for this purpose (Lingeman et al., 2002).

The first laser that became used as an energy source for lithotripsy was the “pulsed-dye” type. This uses a cumarinic dye that, stimulated by light quanta, emits green light pulses with a duration of 1 µs and a wavelength of 504 nm. This wavelength was chosen because it is absorbed by most stones (excluding cystine calculi), without being absorbed by the surrounding tissues (Grocela and Dretler, 1997). The “pulsed-dye” laser works by producing a plasma bubble, whose expansion and collapse generates a shockwave that can determine the fragmentation of the stone. This type of effect is called the photoacoustic effect (Watson and Wickham, 1986) and characterizes most pulsatile lasers, with the exception of the holmium:YAG (Ho:YAG) and erbium:YAG (Er:YAG) lasers.

Another type of laser that can be used for lithotripsy is FREDDY (frequency-doubled double-pulse Nd:YAG), a modified variant of Nd:YAG that can also emit at 532 nm (half of its wavelength). FREDDY is a solid laser with long pulses, double frequency, emitting wavelengths at 532 and 1064 nm that produce stone fragmentation by a photoacoustic mechanism (Delvecchio et al., 2003; Teichman, 2007). This presents the advantages of low costs and, due to its wavelength, minimal risk of tissular lesions. The laser uses silicon fibers that are highly elastic, a property that makes them ideal for use with flexible ureteroscopes (Teichman, 2007). The efficiency of FREDDY lithotripsy is influenced by the stones’ chemical composition, being lower for cystine or calcium oxalate monohydrate (Dubosq et al., 2006).

The Ho:YAG laser (Fig. 3.27), with pulsed emission, is currently considered the most efficient energy source for intracorporeal lithotripsy.

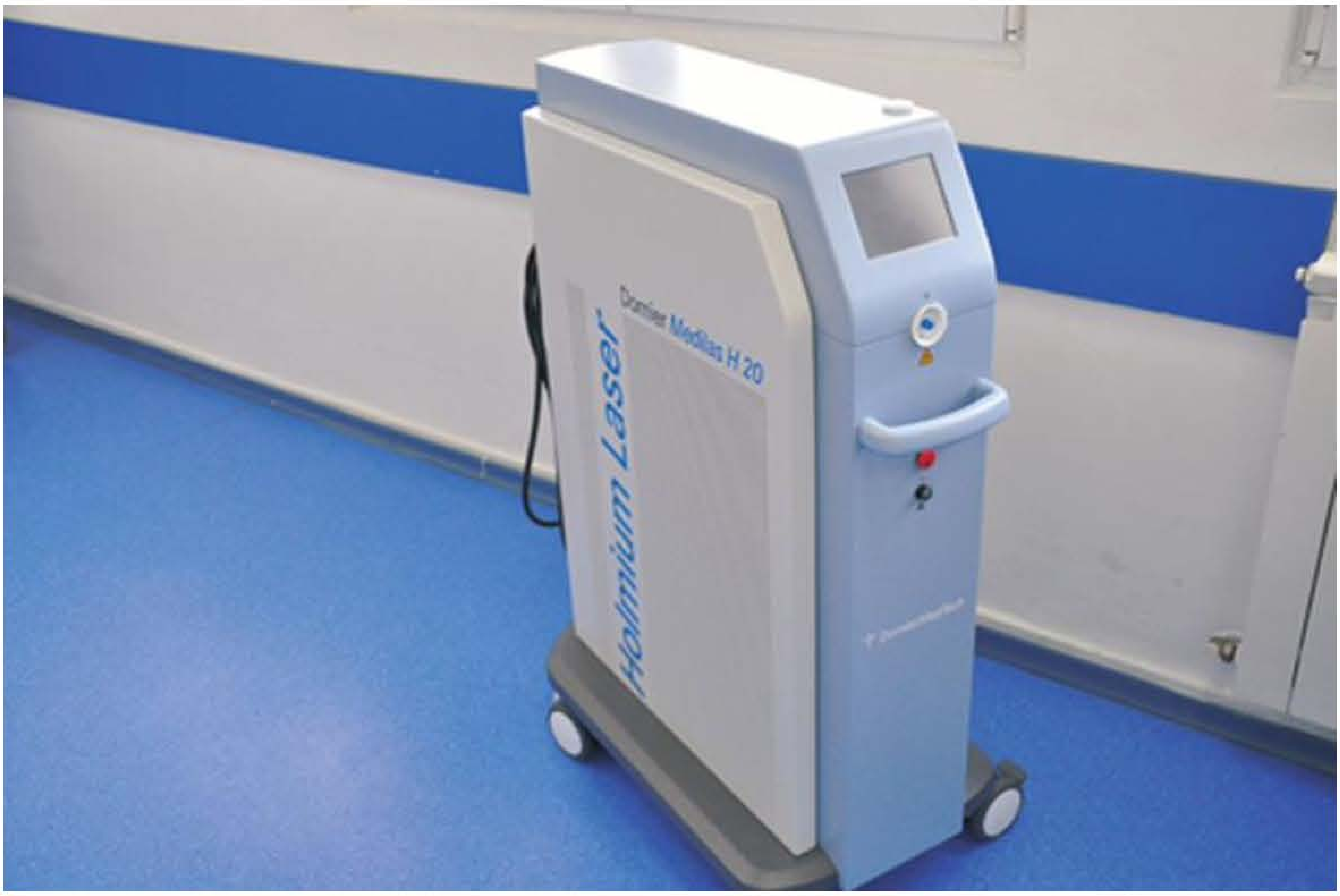

Figure 3.27 **Dornier Medilas H20 Ho:YAG laser.**

Unlike the previously presented types, the Ho:YAG laser has a wavelength of 2140 nm, pulses with a substantially longer duration (250–350 µs), generates nonspherical plasma bubbles (pear-shaped), and produces weak shockwaves. Moreover, some studies show that lithotripsy begins before the collapse of the plasma bubble and the production of the shockwave (Vassar et al., 1999).

All this data led to the theory that the true mechanism of lithotripsy in the case of the Ho:YAG laser is the photo-thermal effect that determines the vaporization of the stones, the photoacoustic effect having an insignificant role (Vassar et al., 1999; Dushinski and Lingeman, 1998; Wollin and Denstedt, 1998; Chan et al., 1999).

Most of the energy of Ho:YAG lasers is superficially absorbed, determining a low penetrability between 0.5 mm and 1 mm (Santa-Cruz et al., 1998; Wollin and Denstedt, 1998). Lithotripsy does not occur when the fiber is applied on the stone at a 90° angle. The Ho:YAG laser can be used on flexible endoscopes, allowing the fragmentation of stones regardless of their localization in the upper urinary tract. The efficiency of Ho:YAG laser lithotripsy varies between 91% and 100% and is not influenced by the chemical composition of the stone. Also, lithotripsy determines the formation of small fragments that do not require additional extraction maneuvers. The mean rates of perforations and of postoperative stenoses are of 1.1 and 1.2%, respectively.

Another advantage of this type of laser is represented by the possibility of using it for incisions of the upper urinary tract. The low penetrability, of only 0.5–1 mm, provides the Ho:YAG with a very good safety profile, currently being one of the preferred modalities for performing these incisions.

The major disadvantage in using the Ho:YAG laser is represented by the high costs of the equipment and fibers.

Due to the photo-thermal effect, various chemical reactions take place during lithotripsy, depending on the chemical composition of the stone. Thus, during lithotripsy of uric acid stones, production of cyanide has been demonstrated, but in low amounts and without clinical significance (Zagone et al., 2002; Corbin et al., 2000).

A new type of laser is the Er:YAG (Fig. 3.28), which acts through a photo-thermal effect similar to that of the Ho:YAG laser. Er:YAG has a 2940 nm wavelength, which is absorbed more efficiently by urinary stones than the 2140 nm wavelength of the Ho:YAG (Teichman et al., 2000; Teichman et al., 2001). Experimental studies are currently still under way with regard to the development of fibers for this type of laser, for use during endoscopic interventions.

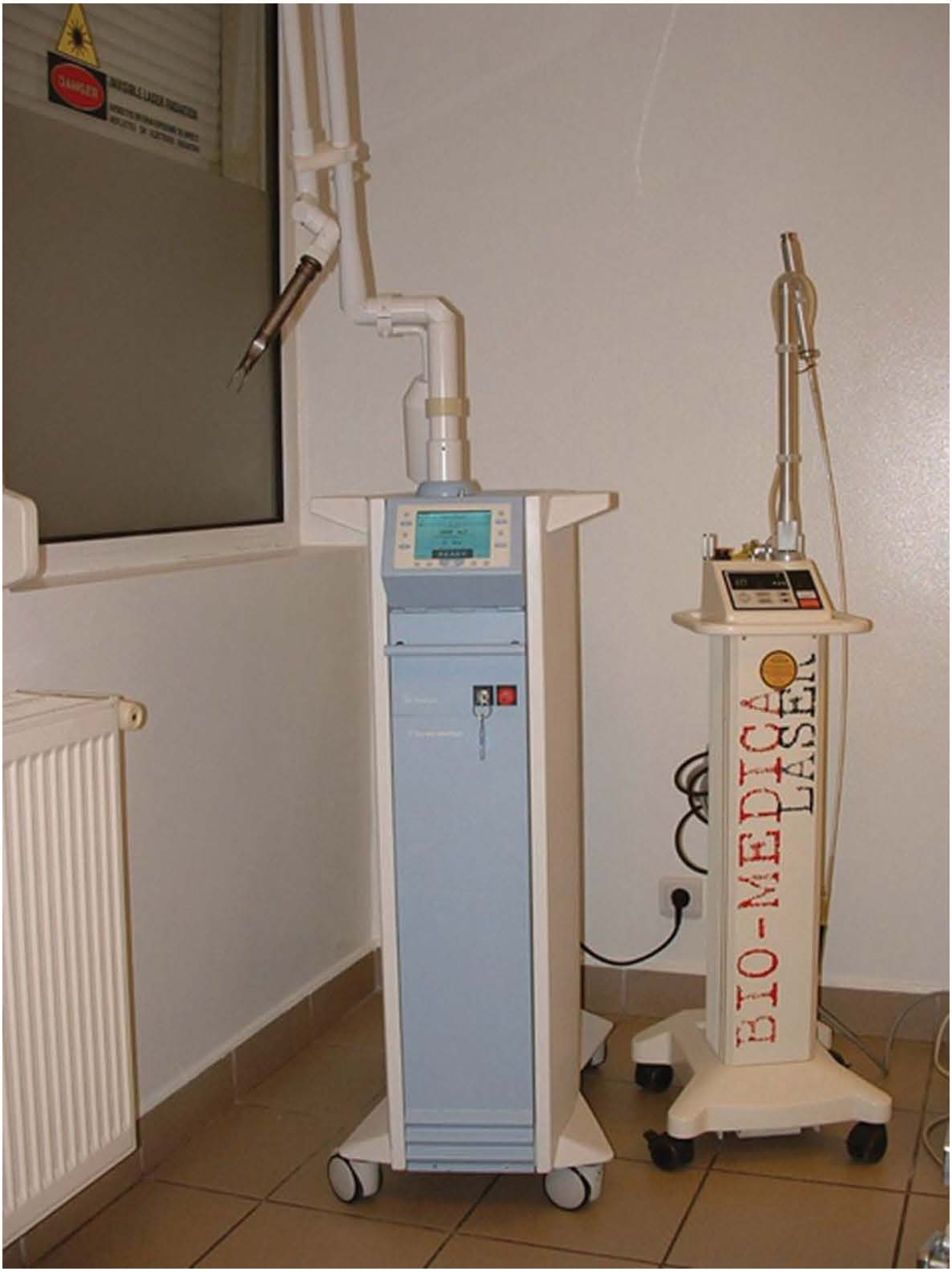

Figure 3.28 **Erbium:YAG laser.**

Nd:YAG (Fig. 3.29) is a continuous emission laser with a wavelength of 1064 nm. The main tissular effect is represented by coagulation necrosis. Nd:YAG has a tissue penetration depth of 5–6 mm and excellent hemostasis capabilities. However, due to this penetrability, its safety margin is much lower than that of the Ho:YAG laser, imposing caution during its use in the upper urinary tract.

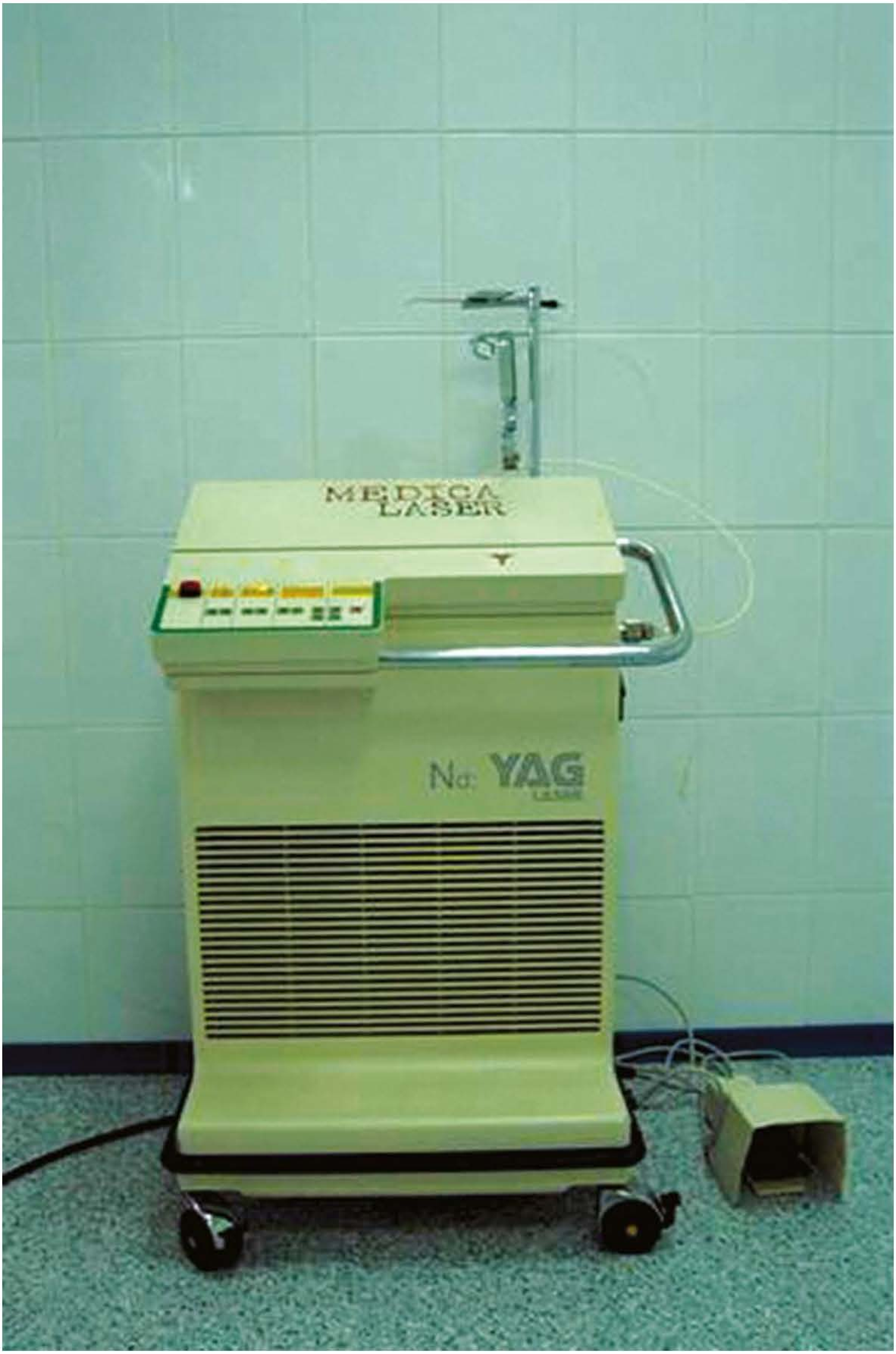
MEDICA
LASER
Nd: YAG
LASER

Figure 3.29 **Dornier Nd:YAG laser.**

The Nd:YAG laser can be used to perform incisions or for tumor tissue destruction. For optimal effects, the laser fiber (Fig. 3.30) must not come into contact with the tumor.

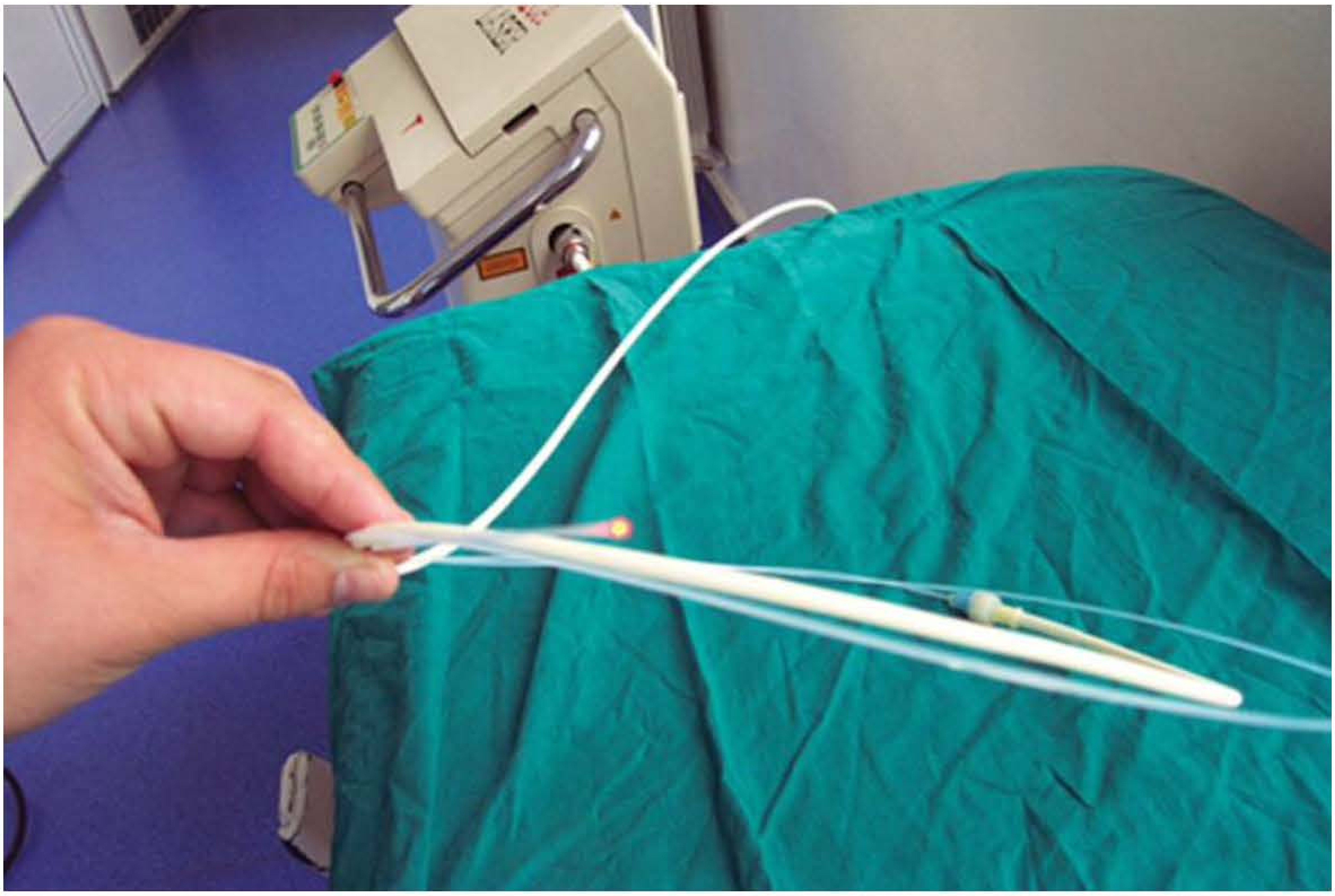

Figure 3.30 **Linear fiber (600 μm) for Dornier Nd:YAG laser.**

3.5.5. Energy Sources for Electrosurgery

Electrosurgery applies the use of alternative radiofrequency currents for cutting and/or coagulating tissues.

The electrosurgical devices are monopolar or bipolar. In the case of the first type, the electric current from the electrode placed on the working instrument reaches the site of the lesion and from here, through the patient's body, reaches a second electrode, placed externally, most frequently on the buttock or thigh. In the case of bipolar systems, the current from the site of the lesion returns to a second electrode that is also located on the working instrument. This particularity reduces the extent of the deep tissular lesions or of those lateral to the application area (Tucker, 2007).

Electrosurgery generators are able to generate three types of current: cutting, coagulation, and combined. Therefore, with the aid of the electric current, one can perform the cauterization of bleeding lesions, the incision of upper urinary tract stenoses, and resection and/or coagulation of tumoral tissue, etc.

The electric current can be applied at the site of the lesion using a wide palette of accessory instruments.

Uretero-resectoscopes (Fig. 3.31) are rigid endoscopes with a diameter ranging from 10.5 F to 13 F, with a mobile working element similar to that of the resectoscopes used in low endourology. Electrodes for tumor resection or knives for electric incisions (hot-knife) (Fig. 3.32) or for cold-blade incisions (cold-knife) of the stenosis areas can be adapted on the working element.

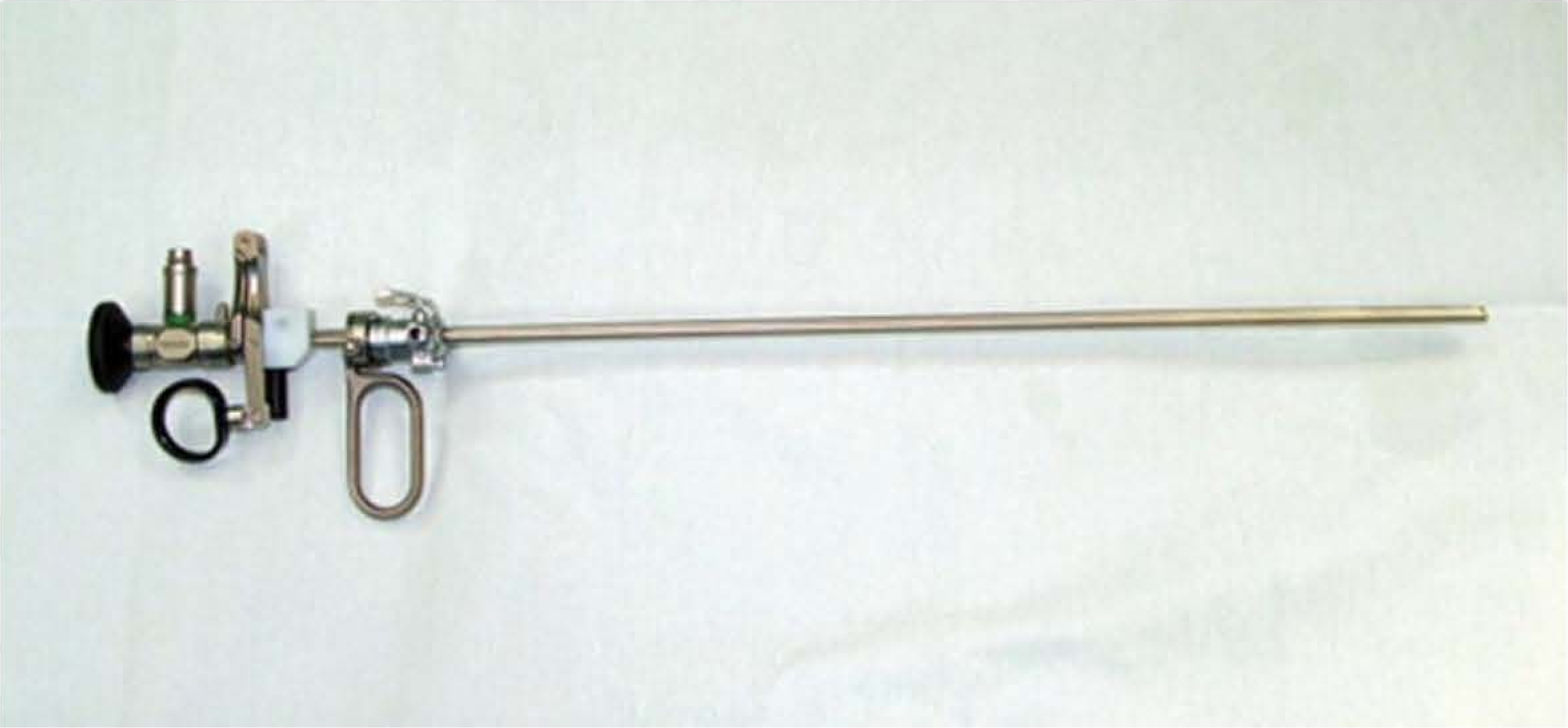

Figure 3.31 Storz uretero-resectoscope (Karl Storz Endoscopy, Tuttlingen, Germany).

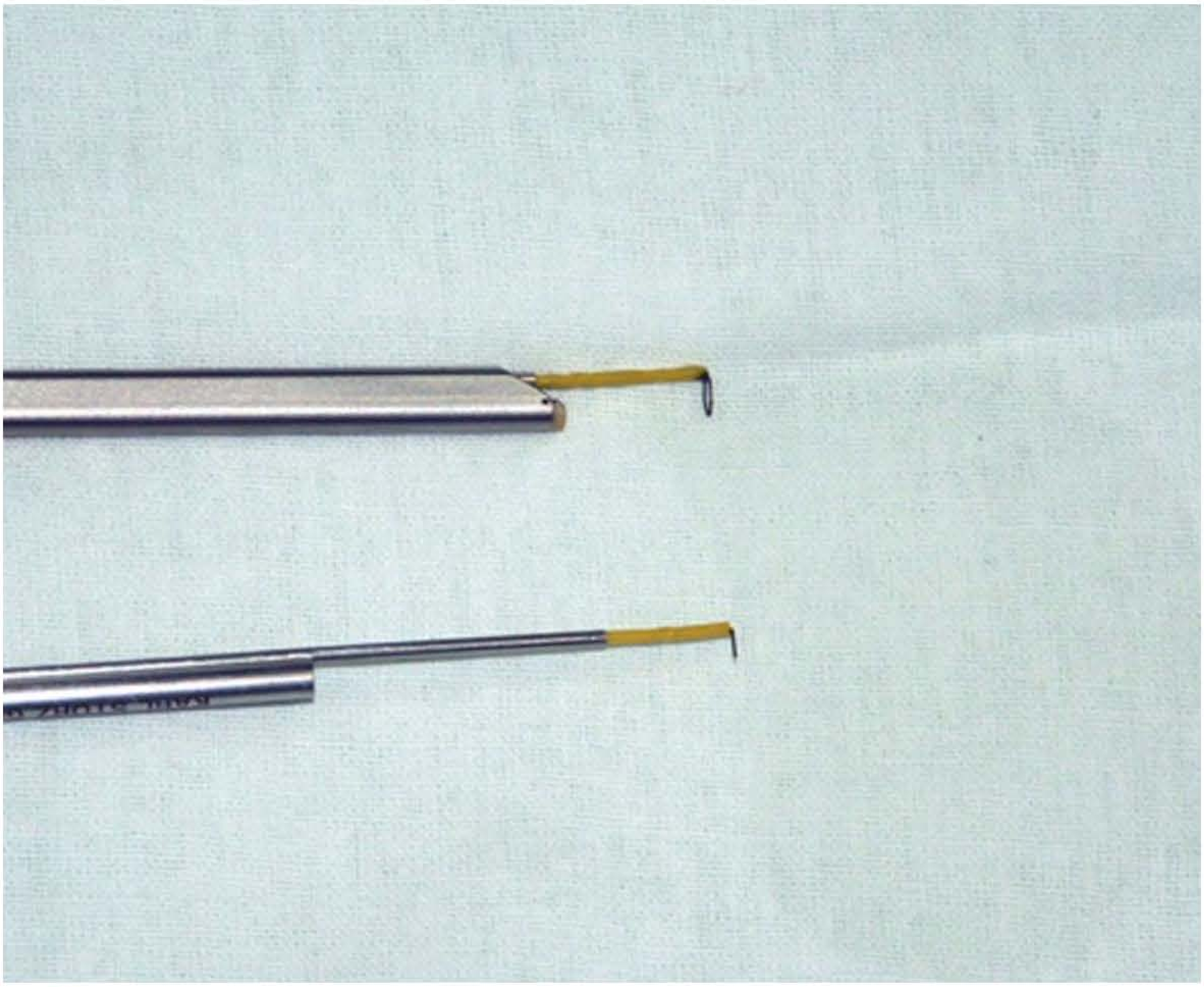

Figure 3.32 Working elements of the Storz uretero-resectoscopes: loop (above) and Collins knife (below).

The electrodes can be used for incision, cauterization, or electrovaporization. They have dimensions ranging from 3 F to 5 F, can be monopolar or bipolar, and can be used on rigid or semirigid ureteroscopes, as well as on flexible ones. Currently there are several types of such electrodes: Hulbert (Cook Urological, Spencer, IN), Bugbee™ and RiteCut™ (Gyrus ACMI, Southborough, MA), and Stryker (Stryker, San Jose, CA), among others. The RiteCut cutting device (Fig. 3.33) has the particularity of presenting an angulation of the distal end, which makes it easier to apply to the wall of the upper urinary tract, increasing the precision and safety of the incisions. The 3 F caliber and the high flexibility allow for its efficient use during flexible ureteroscopy.

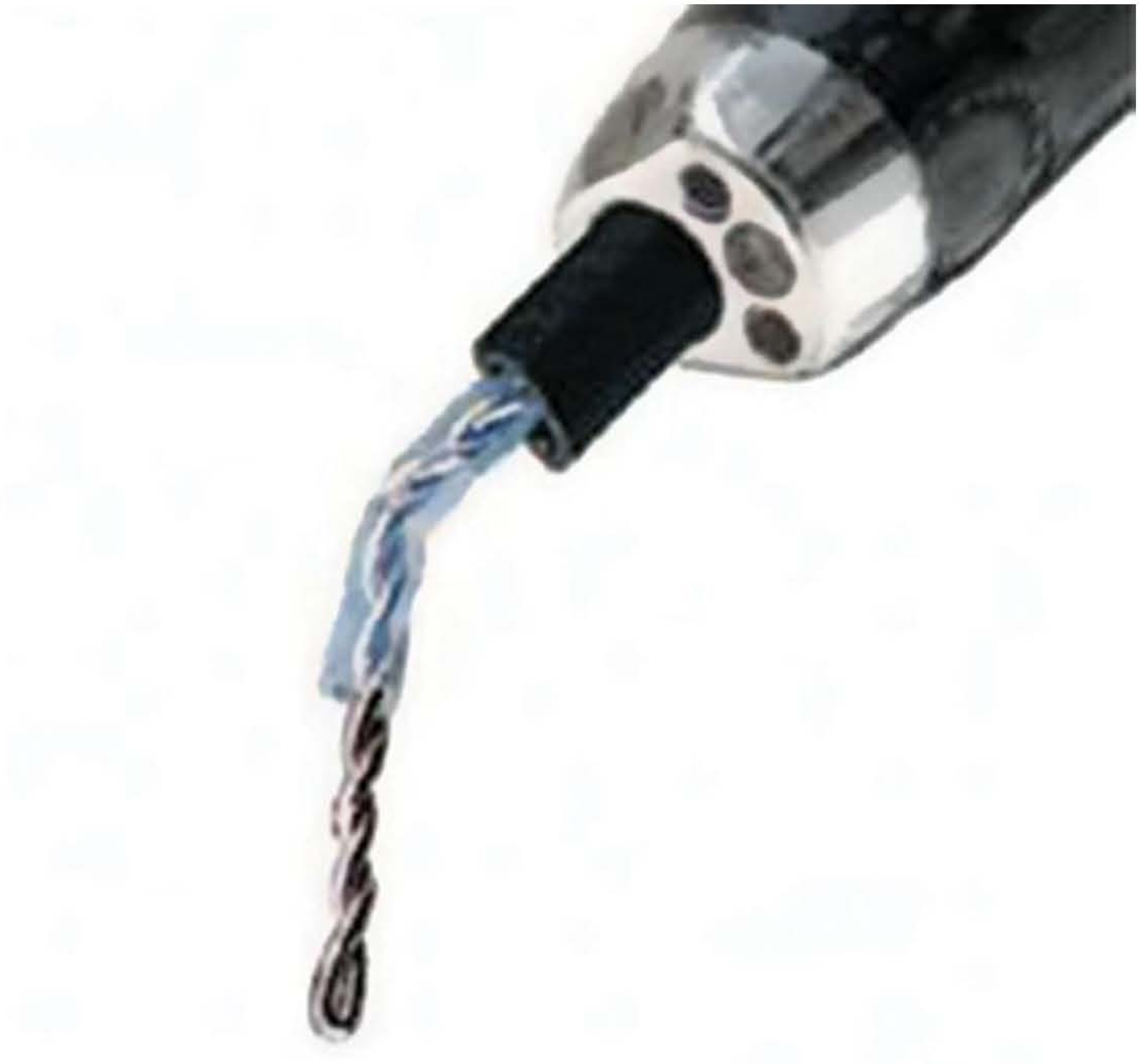

Figure 3.33 **The RiteCut electrode (Gyrus ACMI, Southborough, MA).**

Another device for applying electric current to the upper urinary tract is the Acucise® (Applied Medical, Rancho Santa Margarita, CA), a hybrid between a monopolar electrode and a dilatation balloon (Fig. 3.34). The system is composed of a 6/10 F catheter, with a low-pressure distal balloon (1 atm) with a caliber of 7/13 F (24 F when inflated) to which a filiform electrode is longitudinally applied. This configuration allows one to apply the cutting thread in the desired location and to perform a linear incision, at the same time associating the dilatation and hemostasis effects of the inflated balloon.

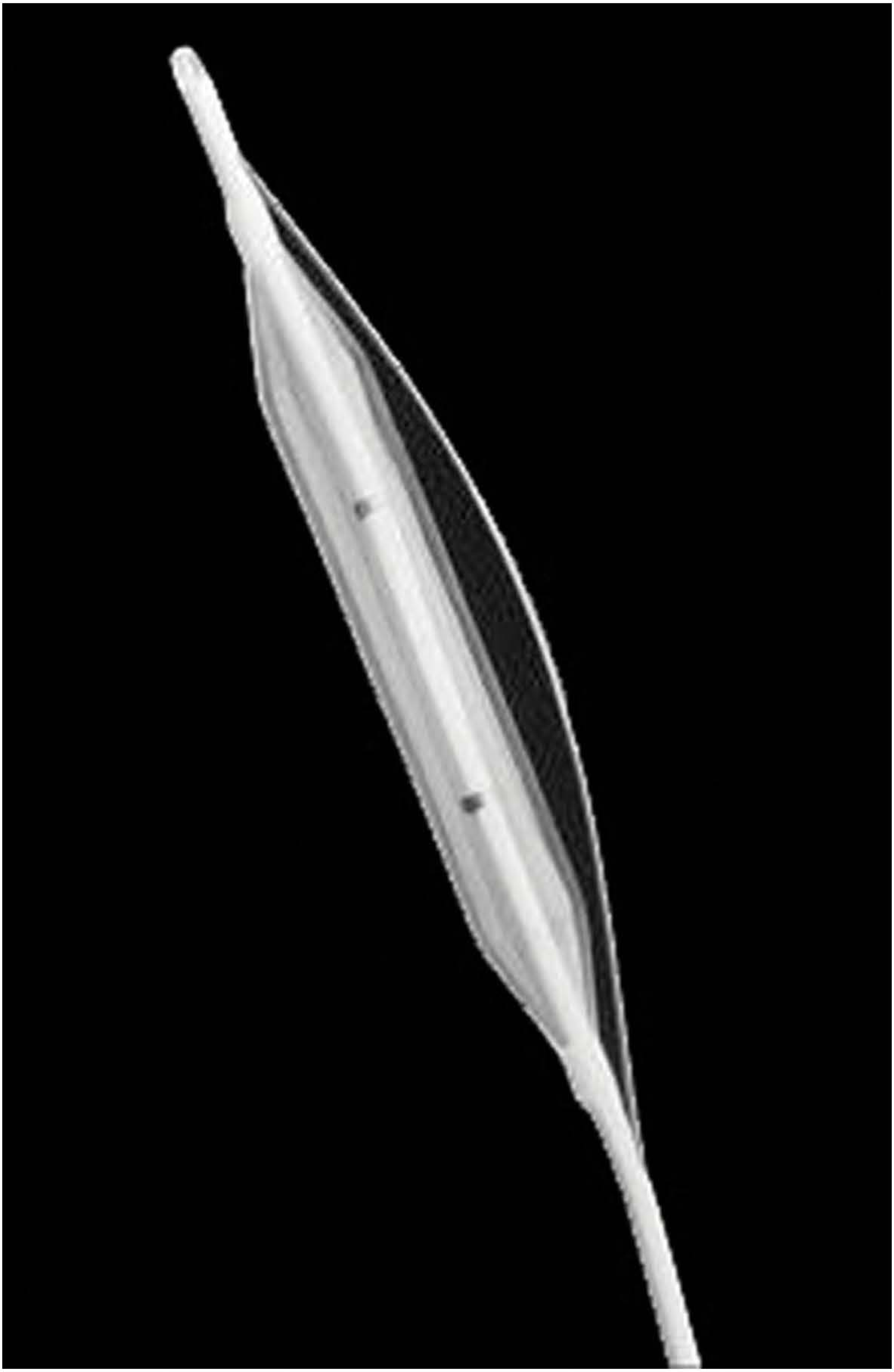

Figure 3.34 The Acucise device (Applied Medical, Rancho Santa Margarita, CA).

3.6. Accessory instruments

3.6.1. Guidewires

The use of safety guidewires (Fig. 3.35) ensures guiding the ascent of the ureteroscope and allows the prevention of ureteral lesions during the dilation of the orifice, ureteroscopy, or stent indwelling.

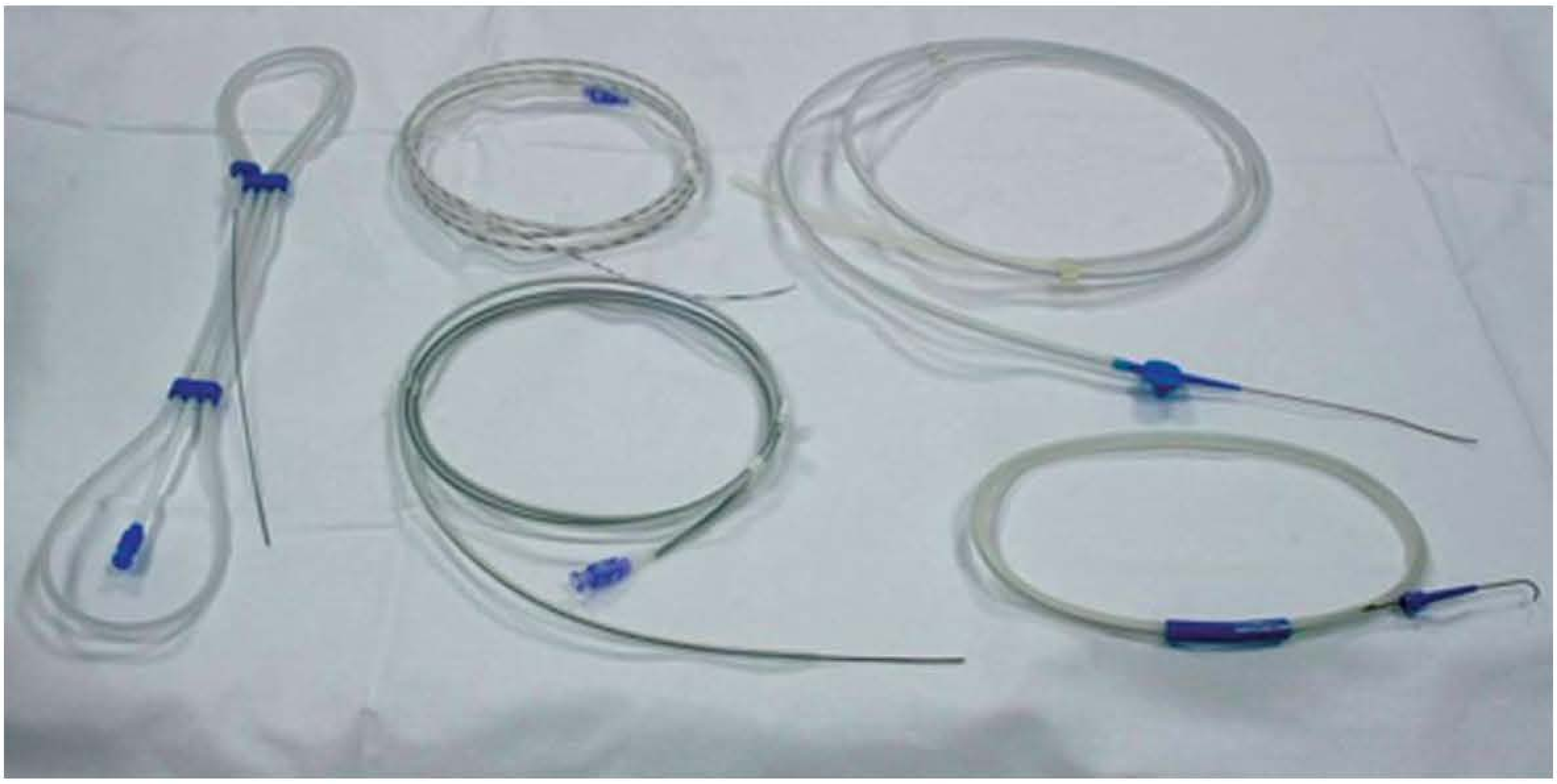

Figure 3.35 **Different types of guidewires.**

The accessibility of different types of guidewires is extremely important, especially in patients in whom a ureteroscopic approach may be difficult (patients with previous interventions on the bladder or ureter, prostate adenoma with a large median lobe, etc.)

Before approaching the ureter, the guidewire must be chosen in conformity with the patient's anatomy, with the disease, and the procedures that will be carried out. In most cases, a standard guidewire with a length of 145 cm, with a polytetrafluoroethylene (PTFE) coating, allows for a safe ureteral access. However, it is absolutely necessary to know the structural and design properties of the different types of guidewires in order to perform the ureteral approach in optimal conditions, especially in difficult cases. Consequently, choosing a proper guidewire determines the increase of the success rate, as well as a reduction of the complications rate and of the duration of the interventions.

The guidewires present four distinctive characteristics: dimensions (diameter and length), the distal end's design, the type of coating, and rigidity.

3.6.1.1. Guidewire Dimensions

Standard guidewires have a diameter varying between 0.018 in. and 0.038 in. (0.05–0.1 cm) and a length between 145 cm and 180 cm. Because flexible ureteroscopes are longer than rigid ones, these may require longer guidewires.

3.6.1.2. Distal End Design

The last 3 cm of the guidewires are flexible in order to minimize the ureteral lesions during ascent. The distal end of the guidewire may be straight, angulated, or in the shape of the letter "J" (Fig. 3.36).

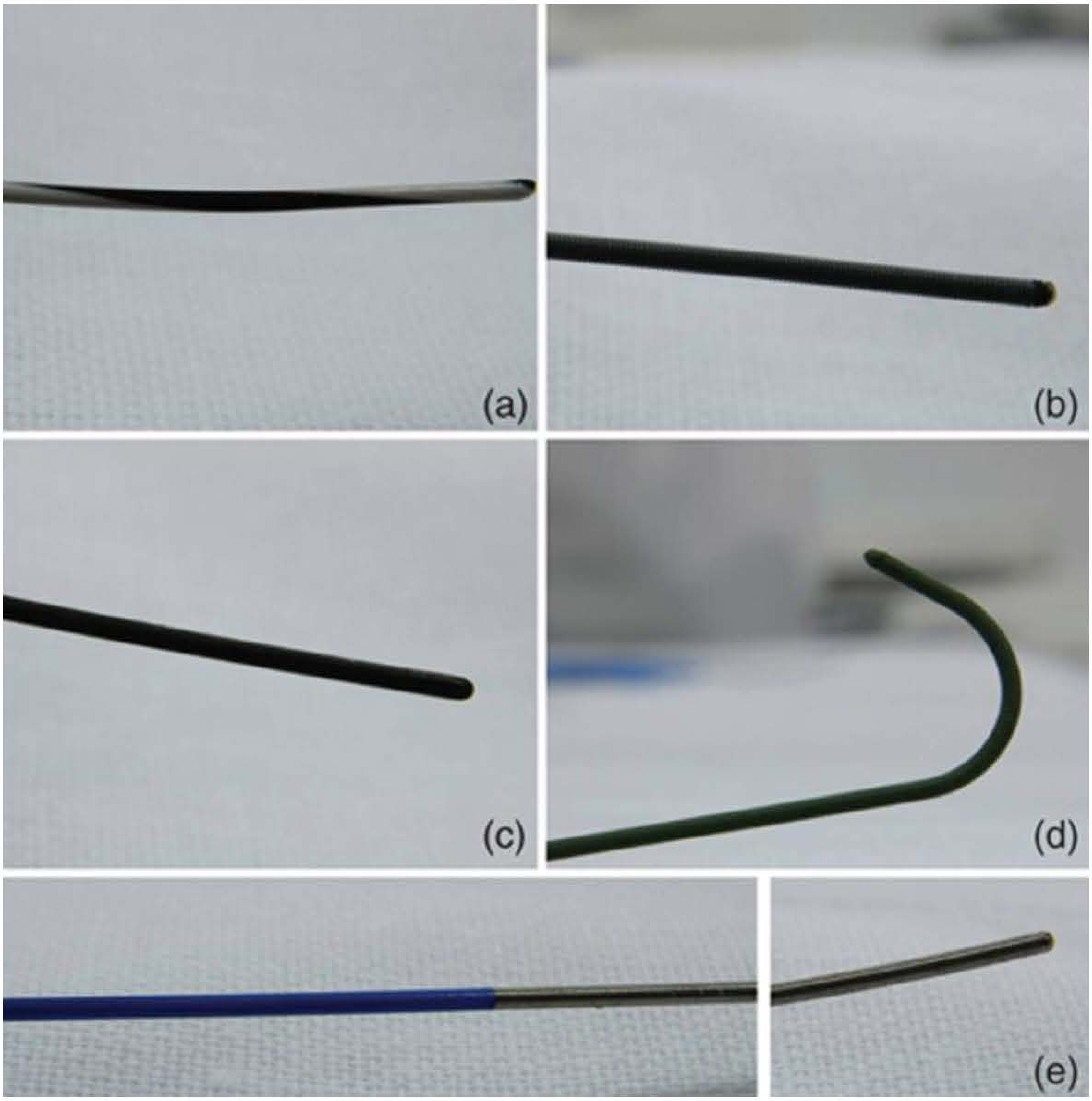

Figure 3.36 Different types of guidewires.
(a) "Super-stiff" guidewire with a straight end, (b) spiral guidewire with a straight end, (c) hydrophilic coated guidewire, (d) spiral guidewire with a J-shaped end, and (e) PTFE-nitinol guidewire.

The guidewires in which both ends are flexible are ideal for flexible ureteroscopy. This design lowers the risk of perforating the working channel when it is inserted retrogradely on the endoscope.

3.6.1.3. Guidewire Surface

The outer layer of the guidewires must ensure minimal friction of their surface. Most guidewires are covered either with a PTFE layer or with a hydrophilic polymer, which allows for easy advancement of the rigid or flexible ureteroscopes (Fig. 3.36). Moreover, most ureteral stents can be easily ascended on the PTFE coated guidewires. The hydrophilic polymer ensures not only a lower friction, but also the flexibility necessary for negotiating through the tortuous ureters or for overcoming impacted stones. In order to ensure these properties, the guidewire must be kept wet during its use.

3.6.1.4. Axis Rigidity

The classic design of guidewires consists of a stainless steel wire twisted around a central mandril. This ensures the rigidity of the guidewire, which can be fixed or can have a degree of mobility in relation with the external sheath, therefore ensuring a variable length of the distal flexible segment.

3.6.1.5. Indications for the Use of Different Types of Guidewires

The standard ureteral approach can be achieved using a 145-cm guidewire, with a 0.038 in. diameter and a PTFE coating that can be advanced under fluoroscopic control. These guidewires have sufficient rigidity for ascending most rigid or flexible ureteroscopes. Miniaturized ureteroscopes require guidewires with a smaller diameter (0.025 in.). The ureteral bends, especially those determined by a large prostate adenoma or by the obstruction determined by an impacted stone, may be overcome by using angled or hydrophilic guidewires. To achieve this, a ureteral catheter with an open distal end is used to intubate the ureteral orifice. The catheter is used as a conduct that facilitates the guidewire's ascent, so that the applied force is directed along the ureteral lumen, lowering the risk of guidewire coiling or of perforation of the wall. The safety guidewire that was initially inserted must be replaced with a firmer one that allows the advancement of a stent or of ureteral dilatators.

3.6.2. Dilation Systems

3.6.2.1. Balloon Dilators

Balloon dilators (Fig. 3.37) represent an accessory used in many endoscopic procedures. Balloon dilators may be used to facilitate the retrograde access (ureteroscopic approach) or the antegrade access (percutaneous approach) to the upper urinary tract.

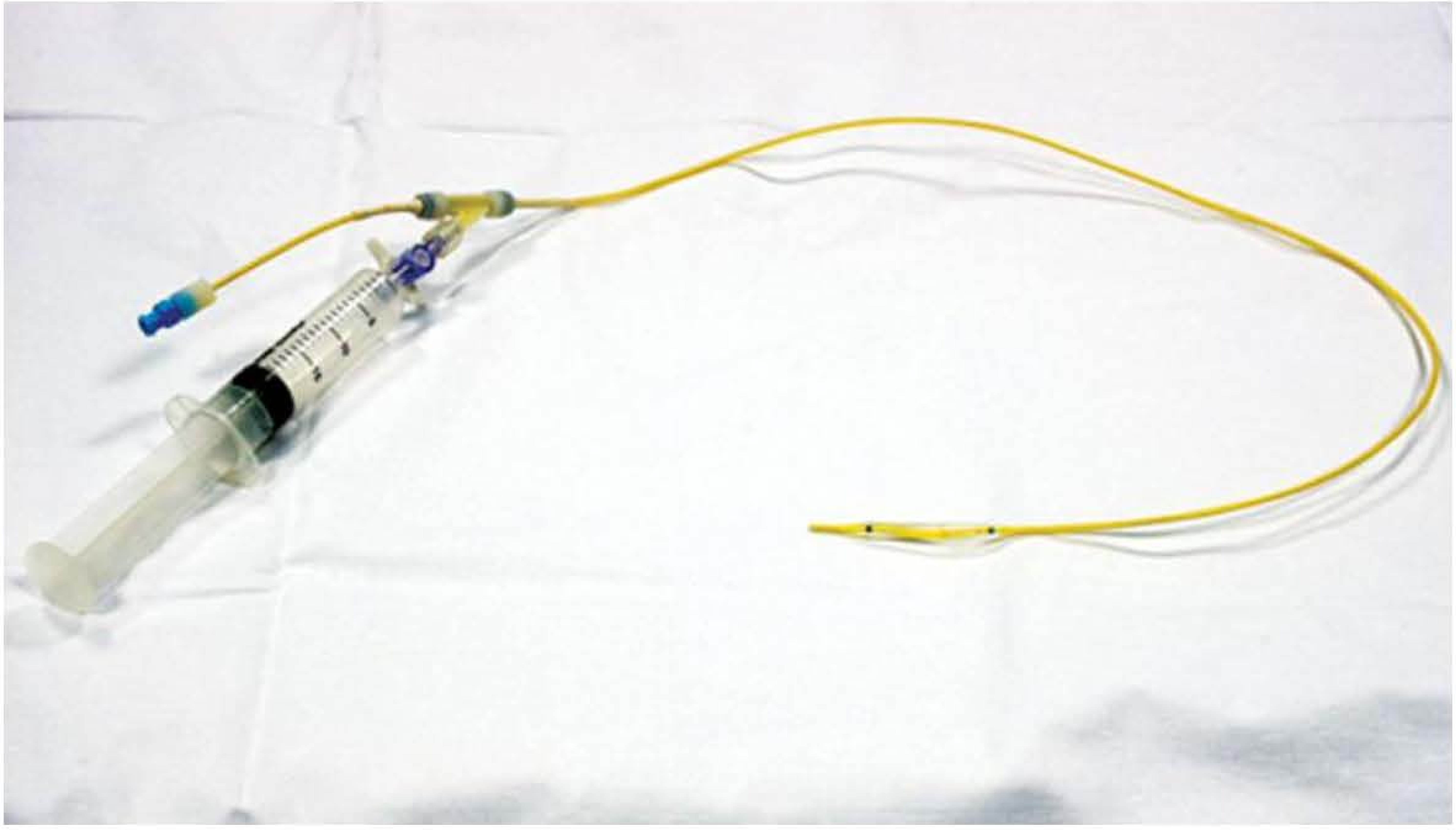

Figure 3.37 **Balloon probe for dilating the ureteral orifice.**

Balloon dilation of the intramural ureter is frequently necessary to ensure a safe ureteroscopic approach of the ureteral orifice. A large enough caliber facilitates the endoscopes' ascent.

Many types of balloon dilators are used in practice. Their required qualities include noncompliance, reduced diameter, and resistance to pressure. Noncompliance represents the balloon's quality to endure stretching and to ensure equal pressure distribution on its entire surface.

The balloon must have, when not inflated, a reduced diameter (close to the catheter's diameter) to allow for a facile insertion and extraction from the urinary tract.

The resistance of the material from which the balloon is made must allow obtaining a high pressure (8–17 atm), without its rupture during the endoscopic maneuvers.

The classic design of balloon dilators includes a flexible segment with a length varying between 30 cm and 150 cm and a diameter of 3–8 F. The proximal end is fitted with two channels. The distal channel allows the passage of a 0.035–0.038 in. guidewire through which the dilator can be ascended. The balloon is inflated by injecting a substance (usually standard saline or saline mixed with contrast media) through the valve of the second channel. The location of the balloon can be established with two radiopaque markers situated at each end. These markers are useful to correctly position the balloon in the area that is to be dilated. The balloon has a length varying between 4 cm and 10 cm, with a maximum diameter between 12 F and 30 F (Fig. 3.38).

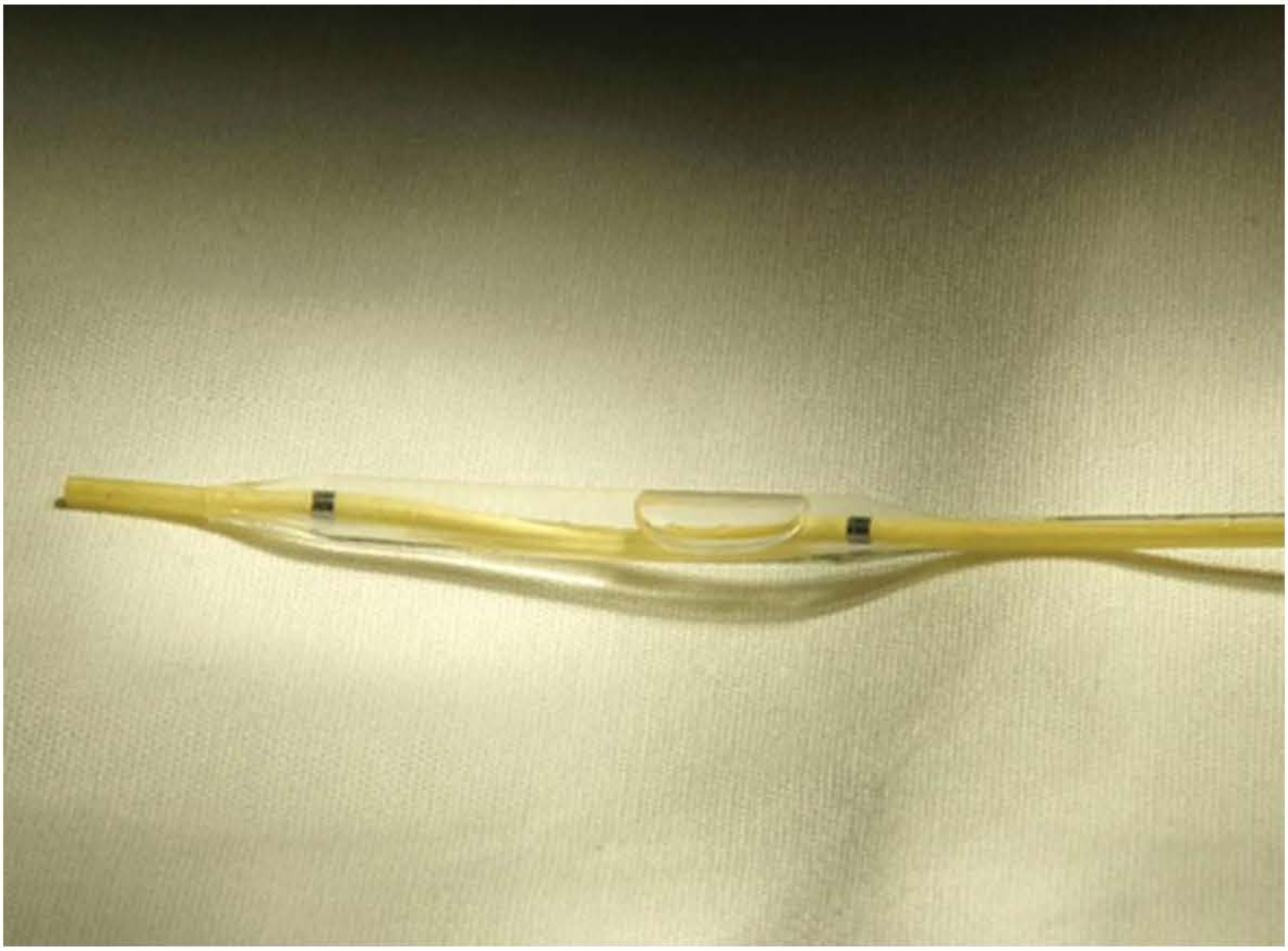

Figure 3.38 Balloon dilator (in detail).

Balloon dilators can have different designs. The ones with a long end allow for a more efficient dilation of the intramural ureter, while the dilators with a short end are useful in narrow spaces, an example being represented by the dilation of an infundibular stenosis or of a caliceal diverticulum.

3.6.2.2. Nottingham Dilators

Nottingham dilators are sets of conical catheters (Fig. 3.39) having a progressive diameter, which are inserted successively by sliding on the metallic guidewire.

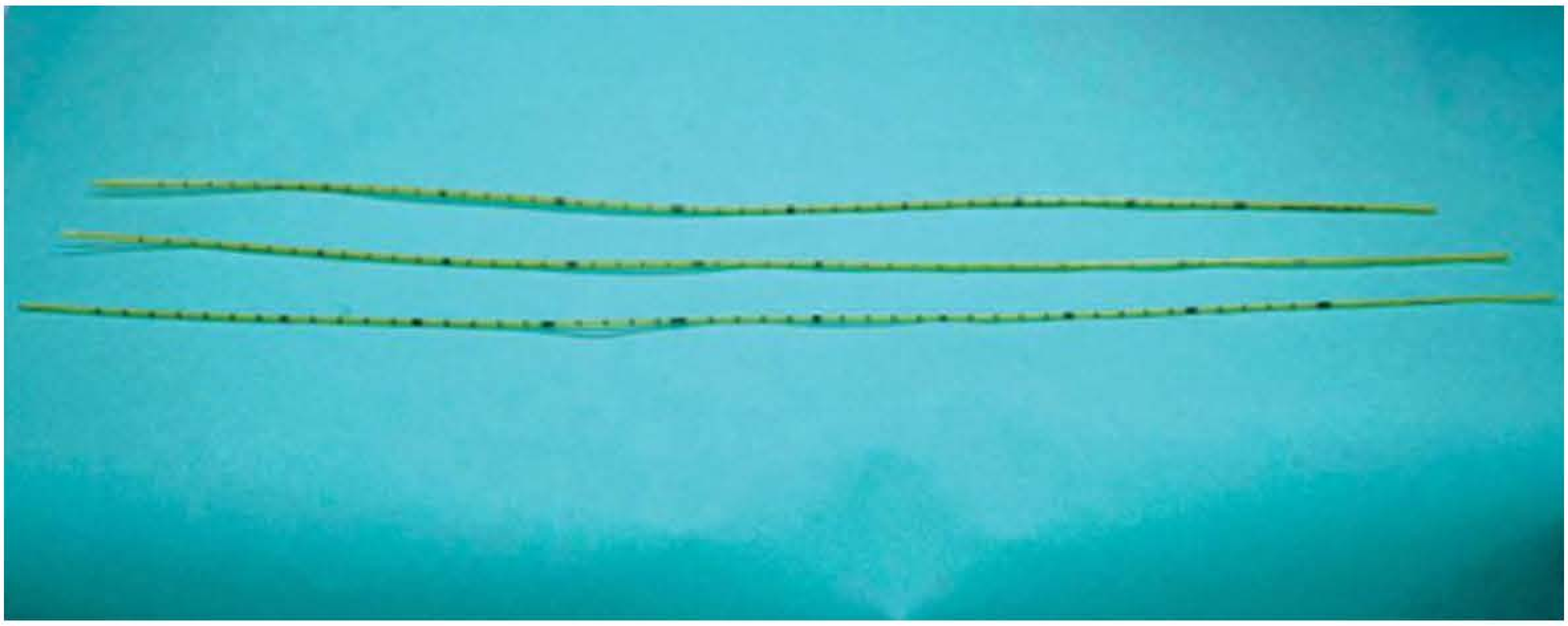

Figure 3.39 **Conical dilator set.**

3.6.2.3. Dual Lumen Catheters

These are catheters with a 10 F diameter used for inserting the two guidewires (working and safety guidewires) into the upper urinary tract and that, due to their caliber, simultaneously achieve dilation of the intramural ureter (Fig. 3.40).

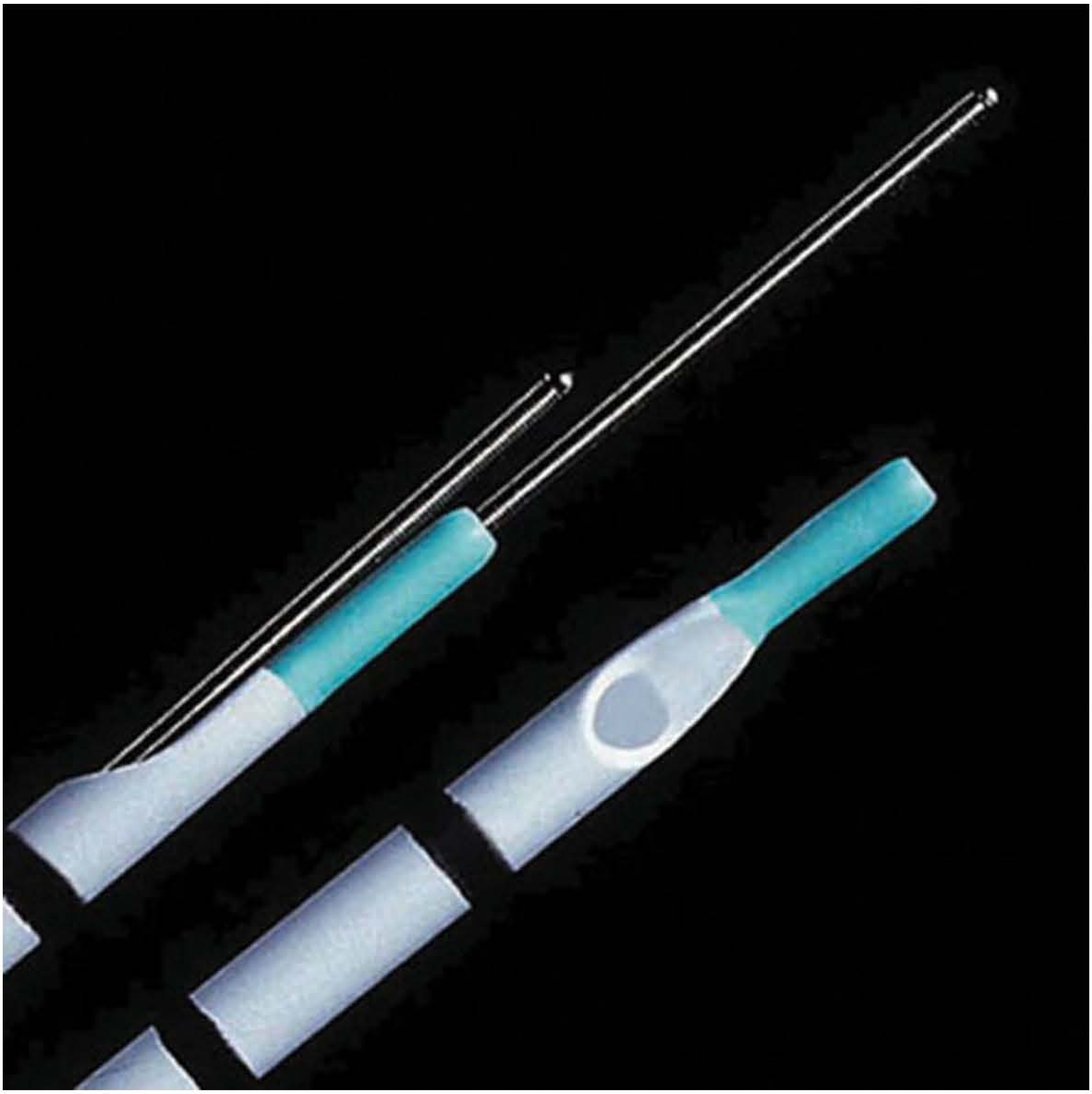

Figure 3.40 **Dual lumen ureteral catheter (Cook Urological, Spencer, IN).**

3.6.3. Ureteral Access Sheath

The ureteroscopic approach may be achieved through a ureteral access sheath. This device is composed of a Teflon dilator fitted with a central channel for the guidewire and a coaxial sheath (Fig. 3.41).

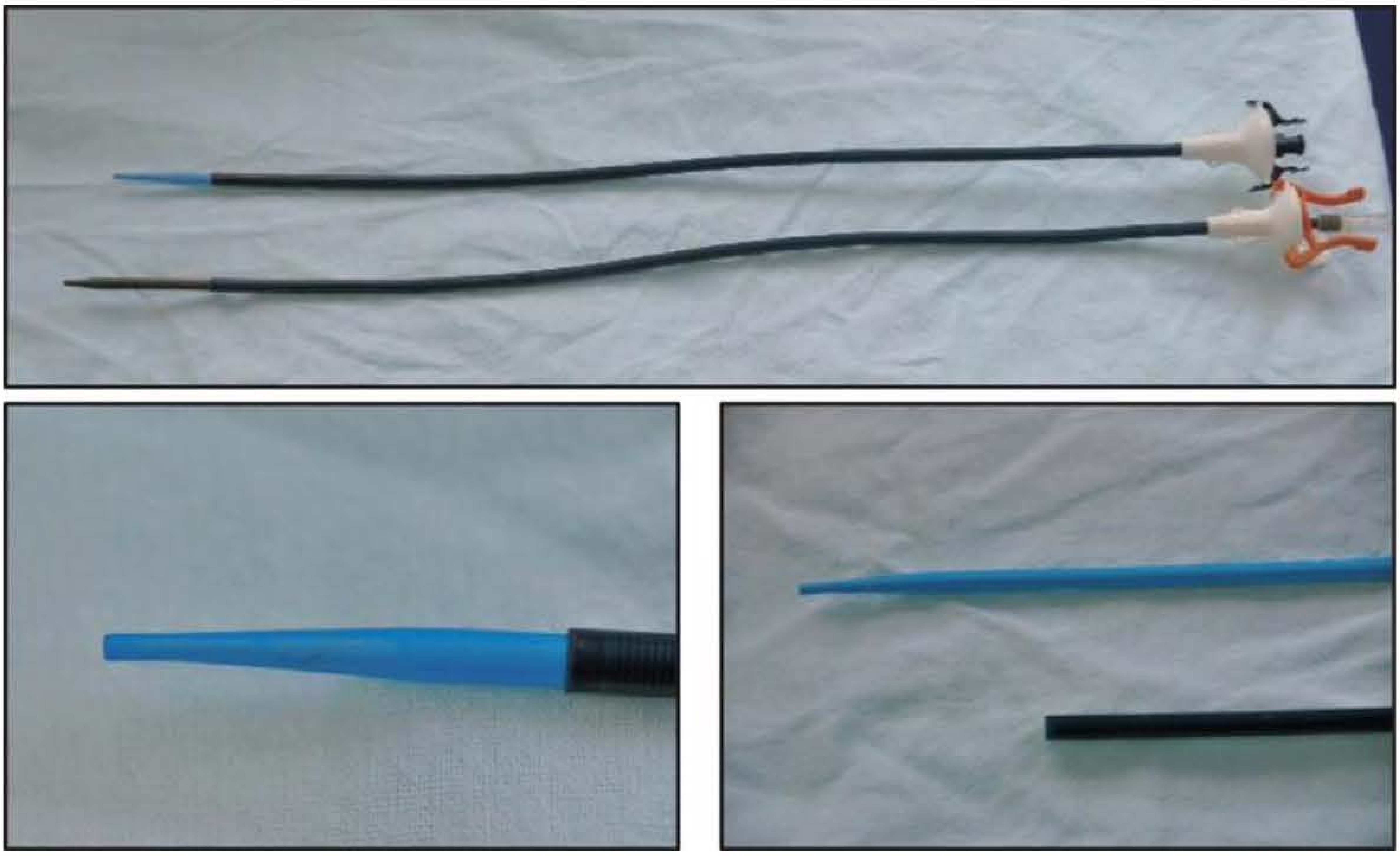

Figure 3.41 **Flexor® ureteral access sheath (Cook Urological, Spencer, IN).**

Although it has only relatively recently been introduced into current practice, it is not a recent invention. Takayasu and Aso reported for the first time in 1974 the use of a Teflon tube to facilitate the approach of the intramural ureter (Takayasu and Aso, 1974). The ureteral sheath currently used was introduced by Newman and coworkers in 1985 (Newman et al., 1985, 1987). These access systems have not been widely used, especially because of the difficulties in placing them. Recently, they have started to be used again, especially due to the new materials that ensure a rigid access sheath with a relatively low thickness profile. Some centers have reported using them only in flexible ureteroscopy (Pietrow et al., 2002), while others also use them occasionally in rigid ureteroscopy (Kourambas et al., 2001).

A new ureteral sheath model allows the placement of the access guidewire only at the distal end of the central piece, outside the external sheath. This area has a longitudinal channel through which, once the device is placed in the desired area, the central part can be extracted, but maintaining the guidewire in place (Fig. 3.42). In essence, after this maneuver, there is a ureteral access sheath that has been correctly placed and a safety guidewire on its exterior, an extremely convenient situation in the conditions of potential complications.

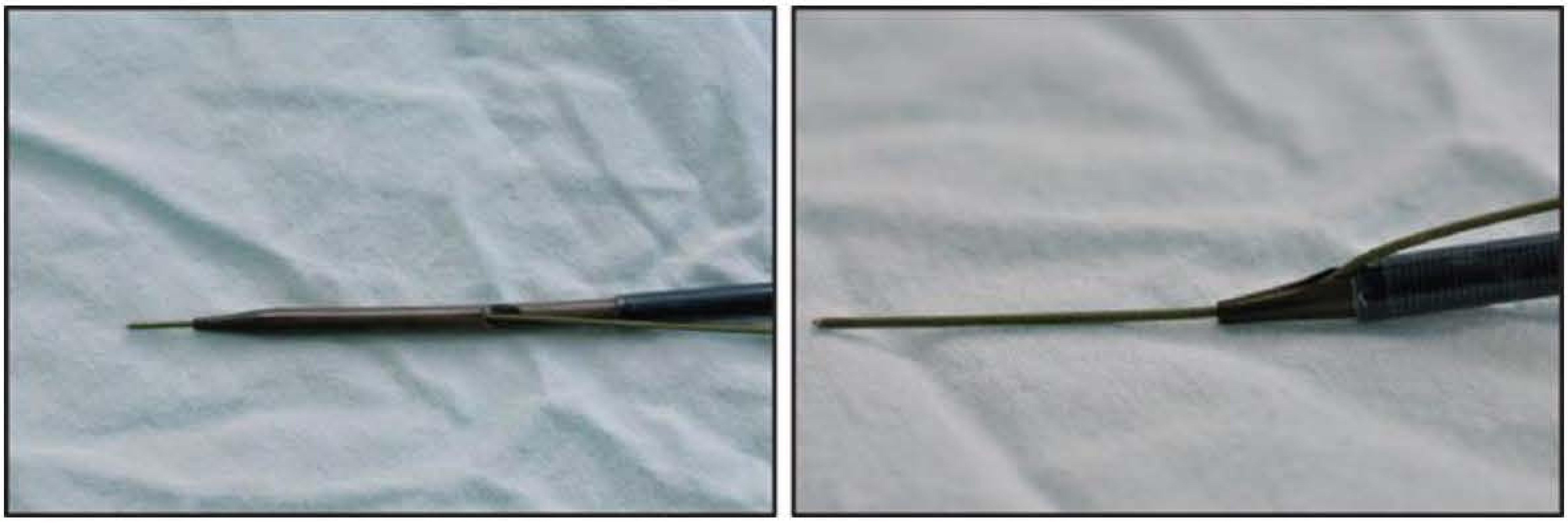

Figure 3.42 **The extraction of the central piece of the access sheath, while maintaining the guidewire in place.**

The ureteral access sheath allows for the atraumatic dilatation of the distal ureter and the easy reinsertion of the ureteroscope, if repeated passages are required (Pietrow et al., 2002). Also, bending of the ureteroscope can be prevented while being advanced, increasing the instruments' durability (Monga et al., 2002). Another reported advantage

(Monga et al., 2001) is represented by the improvement of the irrigation fluid's evacuation around the ureteroscope.

3.6.4. Extraction Instruments

A large variety of instruments have been conceived for the maneuvers of extracting foreign bodies, stones, or fragments resulting after contact lithotripsy. Stone extractors have been used in practice since 1926 (Councill, 1926).

In 1970, the basket probe was introduced, which, until the recent technological advances, was the most frequently used accessory instrument for the endoscopic manipulation of stones (Dormia, 1982). Currently, a multitude of extractors and forceps are available for manipulating foreign bodies or stones in the upper urinary tract. Choosing between them is done according to the particularities of each case.

Classically, most accessory instruments used for ureteroscopy were made of stainless steel. Recently, nitinol (a nickel–titanium alloy) instruments have been introduced into current practice, offering a series of advantages over the classic ones. Steel instruments have a reduced flexibility; nitinol ones have the advantage of a "memory" (returning to their initial shape after the deformation forces stop) and of a superior elasticity compared to other materials. These qualities offer the superiority of nitinol instruments in manipulating reno-ureteral stones (Gotman, 1997). The diameter of accessory instruments has been reduced, so they can be inserted through the 3.4 F working channel of the flexible instruments. In order to ensure a proper irrigation during flexible ureteroscopy, the diameter of the working instruments should be smaller than 3 F.

3.6.4.1. Basket Probes

The design of extraction probes may be helicoidal, with plane wires or multispiral. Those with straight wires allow for good stone capture, especially of renal stones, but have a low rate of success in cases with multiple stones (El-Gabry and Bagley, 1999). The spiral aspect of the helicoidal extractors (Fig. 3.43) ensures an increase in the opening force and a secure closing, being ideal for impacted stones. Also, they are useful in the case of ureters that have a rigid or narrow lumen. The configuration of multispiral probes also allows the extraction of multiple small stones.

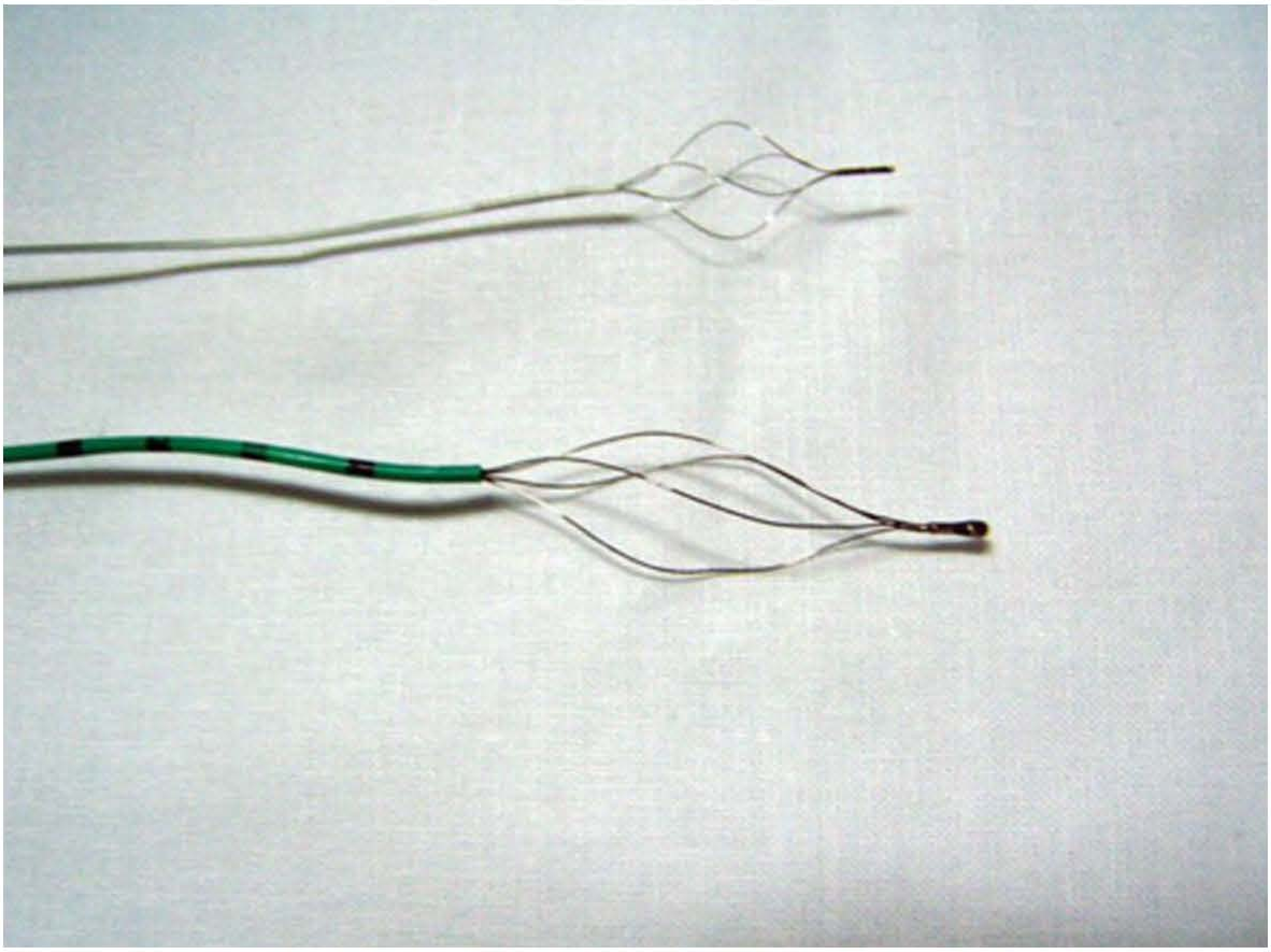

Figure 3.43 **Different types of basket probes.**

The extractor probes may present a filiform or spiraled distal tip (with lengths varying between 1 cm and 9 cm) that has the role of a second guidewire helping to prevent the occurrence of false passages (Vijayan, 1991).

For the approach of caliceal stones, it is necessary to use probes without this tip, distal to the basket (El-Gabry and Bagley, 1999). The first extractor probe with a central channel was produced by Carson et al. (1984) and could be ascended on the guidewire in order to extract the stone under fluoroscopic control. The "blind" extraction of stones implied a high risk of complications, being abandoned with the development of endoscopic techniques. This model is currently used only for ascending laser fibers, with the stone's lithotripsy taking place between the spirals of the probe.

Most extractor probes are fitted with a PTFE sheath. Some authors recommend the removal of the external sheath of the extractor probe; this technical trick increases the performances of the instrument even more (Landman et al., 2002). The manipulation of the extractor probes is achieved through a system placed at the distal end. This can be detached, allowing the removal of the ureteroscope while leaving the probe in place. This design is useful when the stone located between its spirals is fixed. In these situations, for fragmenting the impacted stone, the ureteroscope can be inserted alongside the metallic part of the probe.

The new models of extractor probes, such as Escape® (Boston Scientific, Natick, MA), have a variable number of spirals (2 or 4), depending on the degree of opening, allowing the efficient grasping of the stone, but also an easy release in case of impaction (Fig. 3.44).

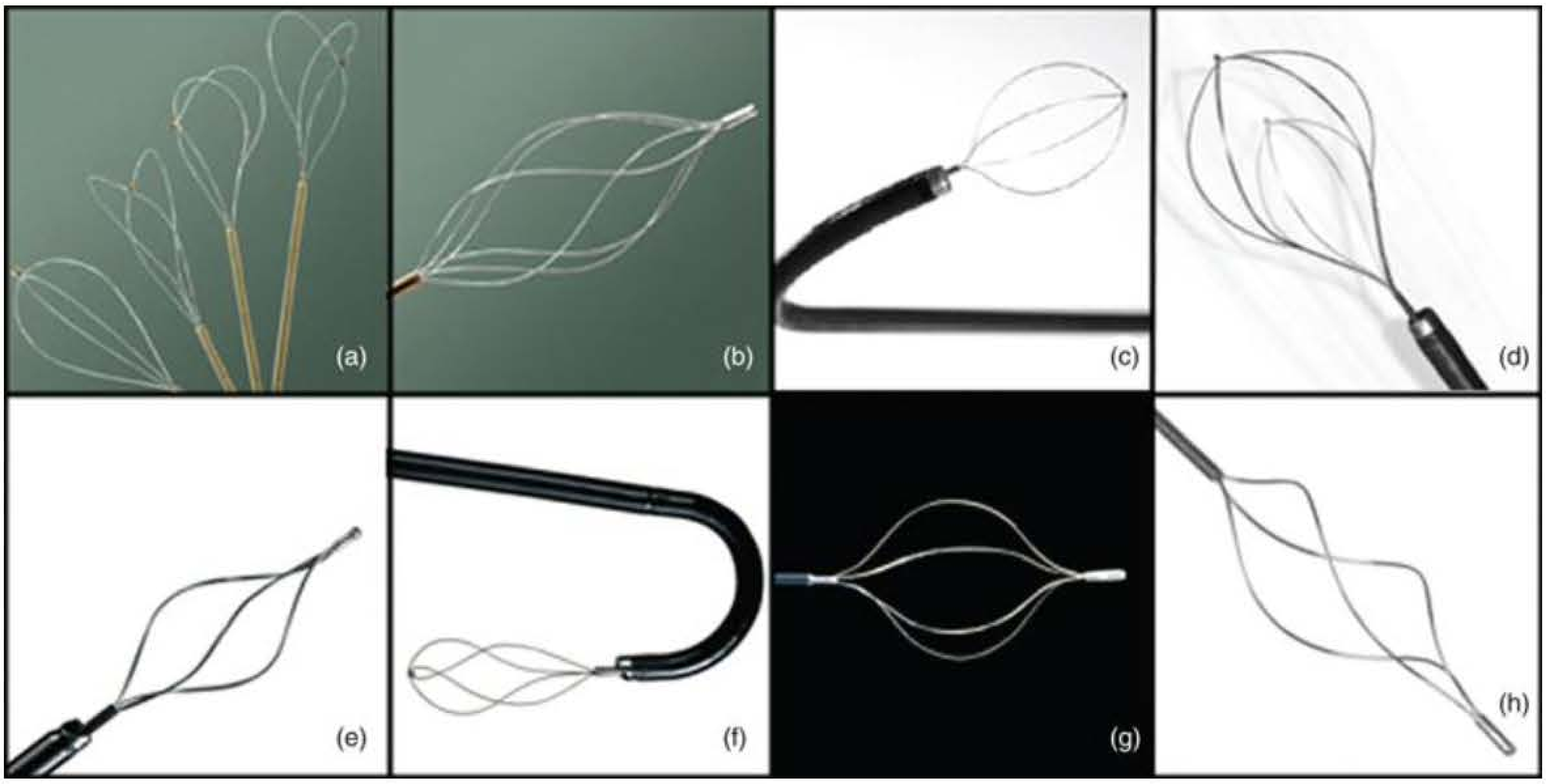

Figure 3.44 **Design particularities of basket probes.**

(a) Dimension™ (Bard Urological, Covington, GA), (b) Expand212® (Bard Urological, Covington, GA), (c) ZeroTip™ (Boston Scientific, Natick, MA), (d) Escape (Boston Scientific, Natick, MA), (e) NForce® (Cook Urological, Spencer, IN), (f) NCircle® (Cook Urological, Spencer, IN), (g) Laser Flat-Wire Stone Extractor (Cook Urological, Spencer, IN), and (h) Captura® (Cook Urological, Spencer, IN).

Other models, such as NCompass® (Cook Urological, Spencer, IN), with a high number of spirals (12–16 helicoidal wires, intersected in a mesh), have a high efficiency in the extraction of multiple lithiasic fragments (Fig. 3.44).

A large array of basket probes with different shapes and sizes is currently available (Table 3.3).

Table 3.3

Particularities of Different Types of Basket Probes

Model	**Manufacturer**	**Dimensions (F)**	**Material**	**Characteristics**
NCircle	Cook Urological	3, 3.2, 4.5	Nitinol	4 helicoidal wires, without tip
NForce	Cook Urological	2.2, 3.2	Nitinol	3 helicoidal wires, with or

				without tip
NCompass	Cook Urological	1.7, 2.4	Nitinol	12–16 wires, without tip, allows the extraction of multiple lithiasic fragments
Atlas Wire™	Cook Urological	1.7, 2.8, 3.2, 4.5	Steel	4 straight wires, with or without tip
Captura	Cook Urological	1.7, 2.8, 3.2, 4.5	Steel	3, 4, 5, or 6 helicoidal wires, with or without tip
Laser Flat-Wire Stone Extractor	Cook Urological	2.5, 3	Steel	4 straight wires, with tip, accepts laser fibers of up to 333 and 512 μm, respectively
Dimension	Bard Urological	2.4, 3	Nitinol	4 wires
Expand212	Bard Urological	3	Nitinol	6 (2-1-2-1) helicoidal wires, with or without tip
Platinum Class™ Flat Wire	Bard Urological	2.4, 3	Steel	4 straight wires, with or without tip
Platinum Class Torque-Stable Helical	Bard Urological	3	Steel	4 helicoidal wires, with or without tip
Sur-Catch™	Gyrus ACMI	2.2, 2.4, 3	Nitinol/Steel	3 × 2 helicoidal wires, with or without tip
SurLock™ Flatwire	Gyrus ACMI	2.4, 3, 4.5	–	4 straight wires, with tip
SurLock Helical	Gyrus ACMI	1.9, 3, 4.5	Steel	3 or 4 helicoidal wires, with tip
Zero Tip™	Boston Scientific	2.4, 3	Nitinol	4 straight wires, without tip
Escape	Boston Scientific	1.9	Nitinol	2 or 4 wires (depending on the degree of retraction)
Gemini™	Boston Scientific	2.4	–	4 helicoidal wires, with or without tip
Segura™ Hemisphere®	Boston Scientific	2.4, 3, 4.5	–	4 straight wires, with or without tip
Stryker Nitinol 4-Wire	Stryker	1.9, 2.4, 3	Nitinol	4 straight wires, without tip
Stryker Flat Wire	Stryker	2.4, 3	Steel	4 straight wires, with tip

3.6.4.2. Extractor Forceps

At present, many types of stone extractor forceps are available (Fig. 3.45) with a diameter of 3 F. These are considered to be safer because they allow releasing the ureteral stones if impaction of the working instrument occurs during the extraction maneuvers.

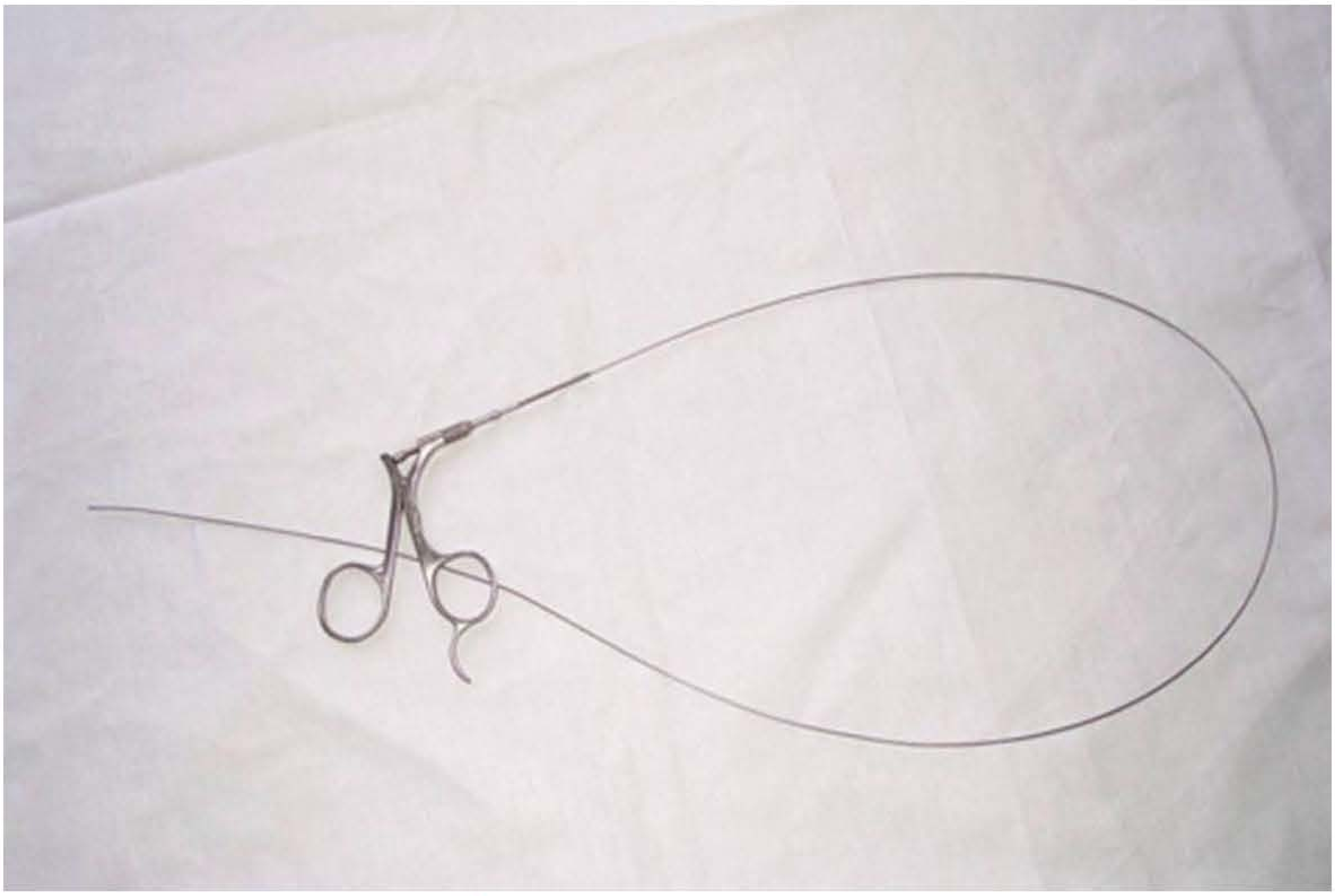

Figure 3.45 **Stone extractor forceps.**

The ureteral extractor forceps may have different dimensions and designs, including “rat tooth” forceps, “alligator” forceps, etc. (Fig. 3.46, Table 3.4).

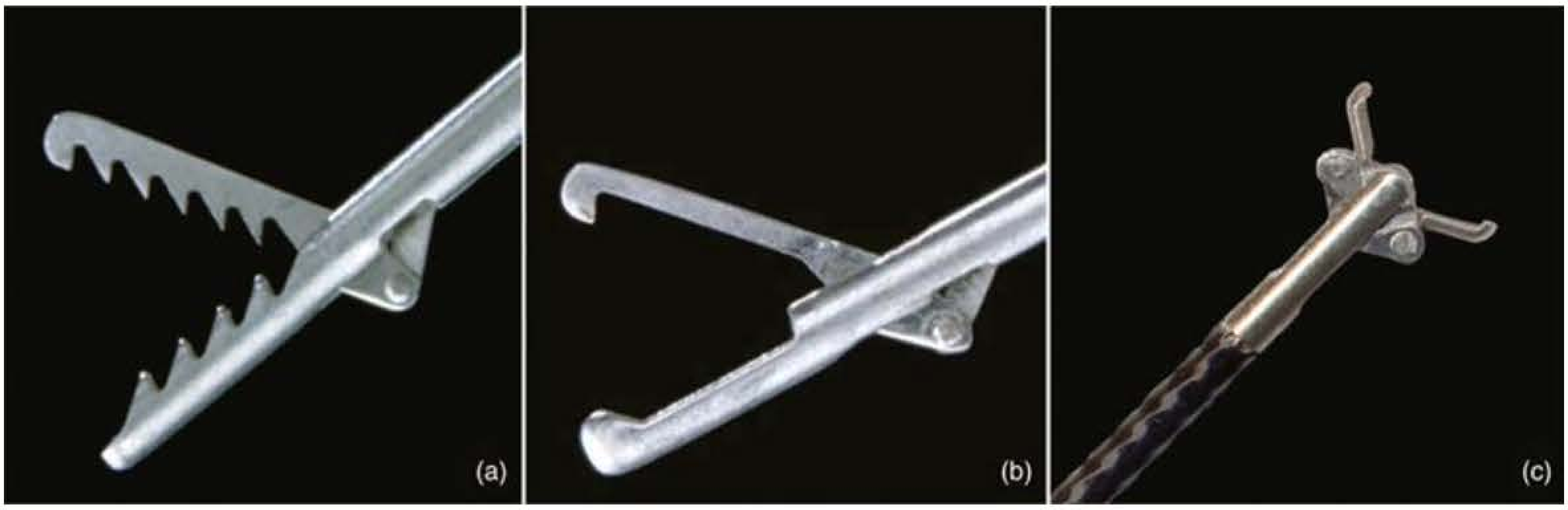

Figure 3.46 **Design particularities of different models of extractor forceps.**
(a) “Alligator,” (b) “Rat-tooth,” and (c) “Mouse-tooth” (Cook Urological, Spencer, IN).

Table 3.4
Types of Forceps Used During Ureteroscopic Interventions

Type	Model	Manufacturer	Dimensions (F)	Compatible endoscopes
Extractor forceps	Alligator Tooth	Cook Urological	3, 5.2	Rigid, semirigid, or flexible
	Mouse Tooth	Cook Urological	3	Rigid, semirigid, or flexible
	Rat-Tooth	Cook Urological	3, 3.3, 5.2	Rigid, semirigid, or

				flexible
	Rat Tooth	Gyrus ACMI	3	Rigid, semirigid, or flexible
Extractor graspers (tripod)	Captura	Cook Urological	2.8, 3.2	Rigid, semirigid, or flexible
	Delta Wire® Grasper	Cook Urological	3.2	Rigid, semirigid, or flexible
	Cook Grasping Forceps	Cook Urological	2.5, 3, 3.5, 5	Rigid, semirigid, or flexible
	SurLok™	Gyrus ACMI	2.4, 3, 4.5	Rigid, semirigid, or flexible
	Bard Grasping Forceps	Bard Urological	3, 4.5	Rigid, semirigid, or flexible
	Platinum Class Non-Retracting	Bard Urological	3	Rigid, semirigid, or flexible
	Tricep®	Boston Scientific	2.4, 3	Rigid, semirigid, or flexible
Biopsy forceps	Cup Biopsy Forceps	Cook Urological	3, 5.2	Rigid, semirigid, or flexible
	Flexible Biopsy Cup Forceps	Gyrus ACMI	3	Flexible
	Flexible Biopsy Forceps	Gyrus ACMI	5	Rigid or semirigid
	Semi-Rigid Biopsy Forceps	Gyrus ACMI	5	Rigid or semirigid

3.6.4.3. Tripod Graspers

These are extractor instruments with three arms that extend from a sheath, usually made of PTFE (Fig. 3.47, Table 3.4). The graspers' opening mechanism is similar to that of the basket probes, with the three arms exerting a similar radial force on the ureteral wall.

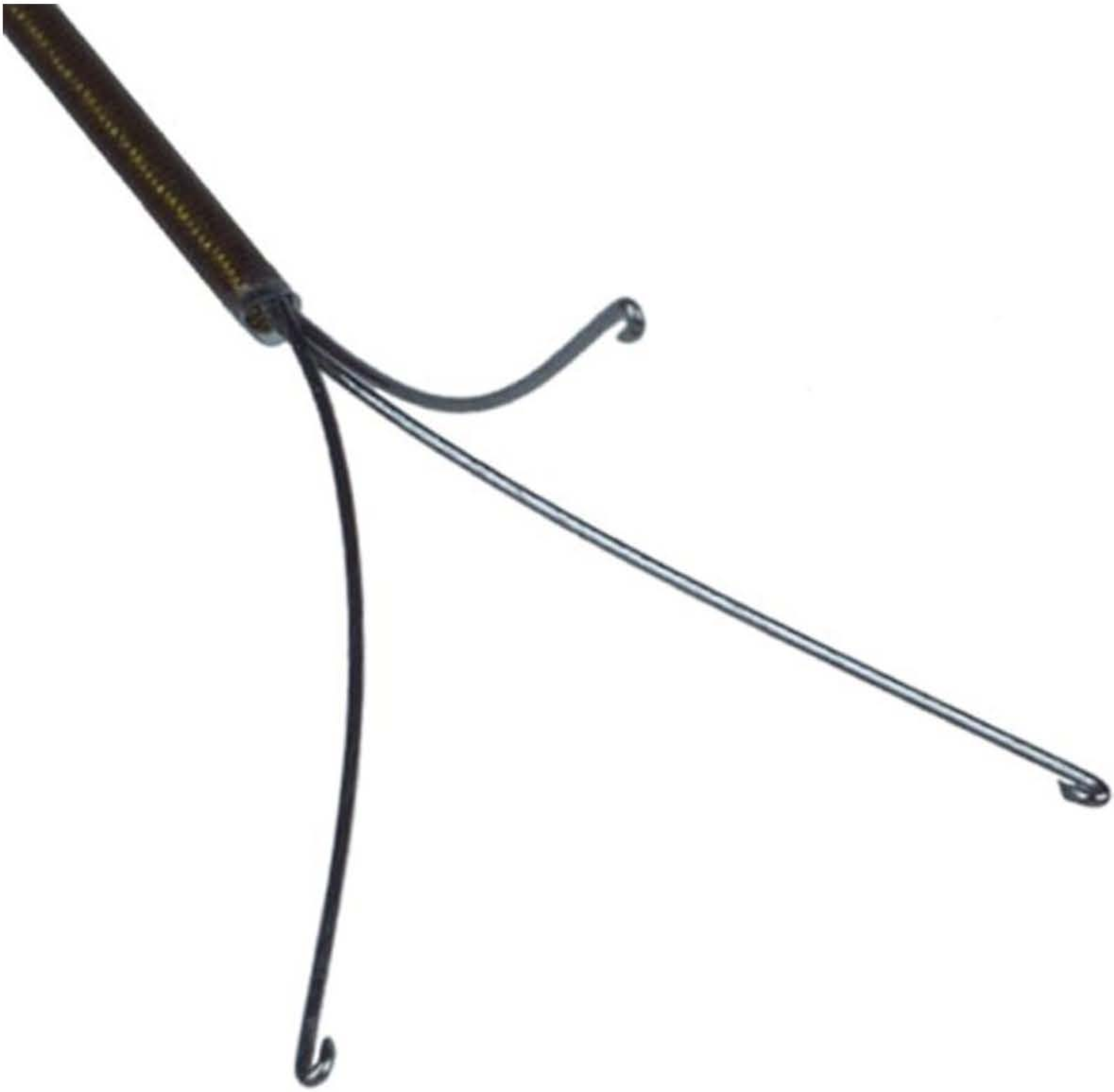

Figure 3.47 **Captura tripod grasper (Cook Urological, Spencer, IN).**

Although the grasping force is smaller compared to extractor forceps, the graspers have the advantage of a high flexibility and a low diameter, being very useful during flexible ureteroscopy. Also, they allow for an easy release of the stone in case of impaction.

3.6.4.4. Other Extractor Instruments

A series of accessory instruments that help increase the success rate of the retrograde ureteroscopic approach have been introduced into urological practice (Table 3.5).

Table 3.5

Technical Characteristics of Other Extracting Instruments

Model	**Manufacturer**	**Dimensions (F)**	**Material**	**Design**
NSnare®	Cook Urological	2.4, 4.5	Nitinol	Loop for extracting foreign bodies or JJ catheters
NTrap®	Cook Urological	2.8	Nitinol	Nitinol wire mesh disposed as an umbrella with an

				occlusive role during lithotripsy
Flat Wire Loop Retriever	Cook Urological	3	Steel	Loop for the extraction of stones, JJ catheters, etc.
Graspit®	Boston Scientific	2.6, 3.2	Nitinol	Hybrid between a basket probe and a grasper
Stone Cone®	Boston Scientific	3	Nitinol	Forms a spiral proximal to the stone preventing the ascent of fragments

A category of such instruments is represented by loops (Fig. 3.48), useful for extracting ascended Cook catheters, foreign bodies, and even lithiasic fragments.

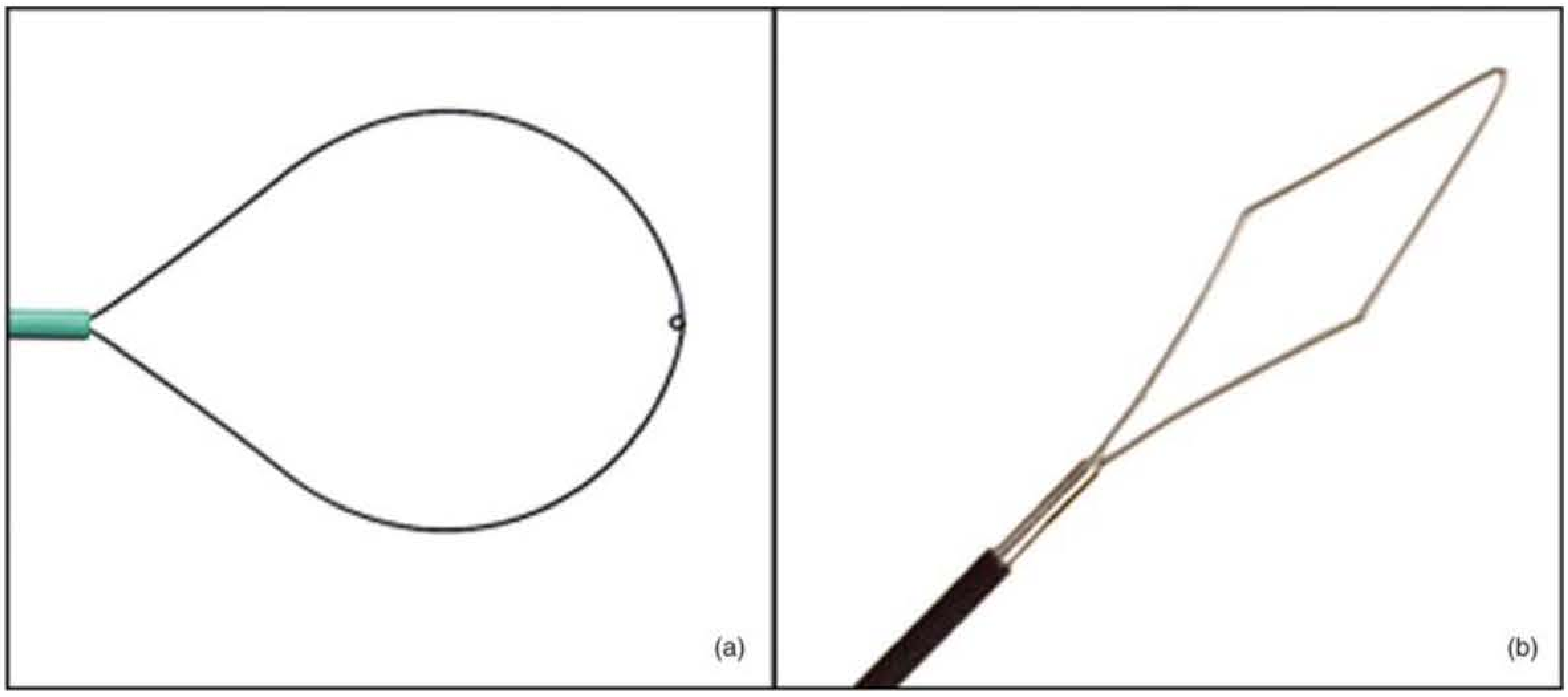

Figure 3.48 **Design features of different models of extractor loops.**

(a) NSnare (Cook Urological, Spencer, IN) and (b) Flat Wire Loop Retriever (Cook Urological, Spencer, IN).

A new stone manipulation instrument was recently introduced into practice, the Stone Cone (Boston Scientific, Natick, MA) or the “Detler cone” (Fig. 3.49), made from nitinol, that forms a spiral proximal to the ureteral stone, preventing its ascent during lithotripsy. After fragmentation of the stones, the retraction of the cone may facilitate their extraction (Dretler, 2001). In a prospective study, this instrument showed a superior success rate compared to other types of probes in the prevention of proximal fragment migration, as well as the elimination of the need for other procedures (Desai et al., 2002).

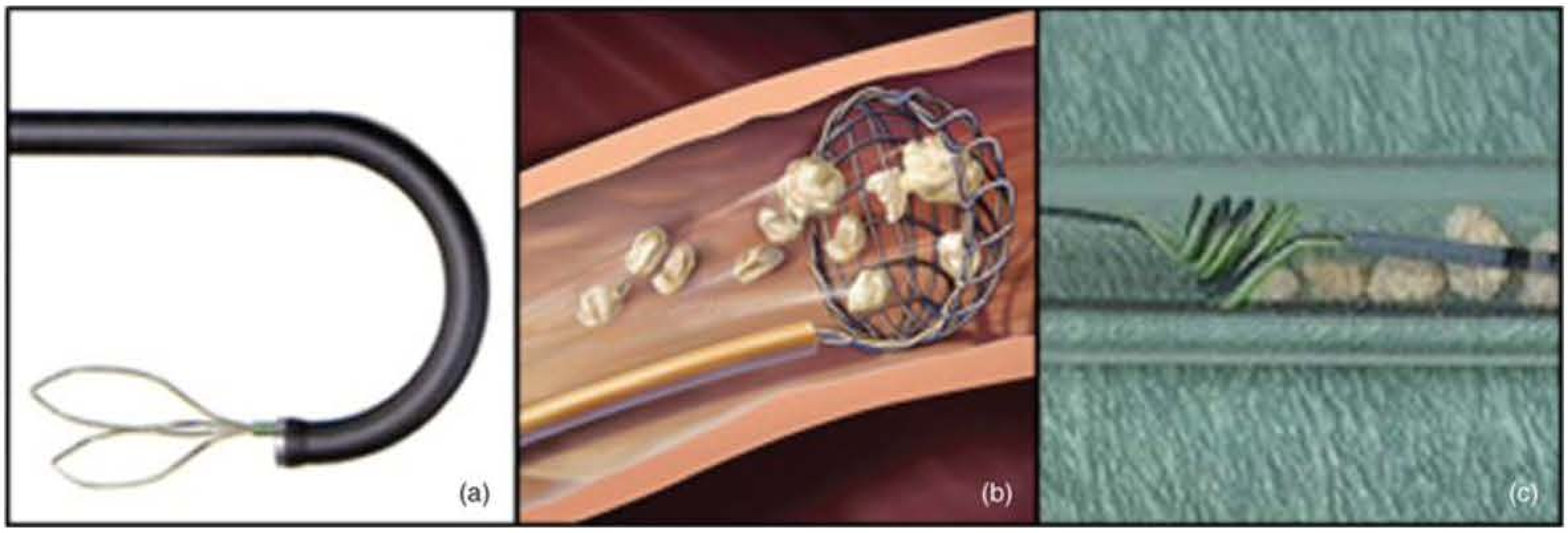

Figure 3.49 **Design features of other accessory instruments with an extractor/occlusive role.** (a) Graspit (Boston Scientific, Natick, MA), (b) NTrap (Cook Urological, Spencer, IN), and (c) Stone Cone (Boston Scientific, Natick, MA).

Graspit (Boston Scientific, Natick, MA) is a hybrid between a grasper and an extractor probe (Fig. 3.49), combining a high grasping force with an easy release in case of impaction.

Also, the design of the instrument allows for the safe approach of caliceal stones. NTrap (Cook Urological, Spencer, IN) is a probe having a particular design, composed of an "umbrella" made of nitinol threads laid out in a mesh (Fig. 3.49), with an occlusive purpose for the ureteral lumen during lithotripsy, and also useful for extracting the resulting lithiasic fragments.

A new occlusive device is the accordion. This has a membrane in the shape of a 10 mm balloon that shortens when it is actioned, taking a cylindrical shape (Fig. 3.50) that captures the larger lithiasic fragments within its folds.

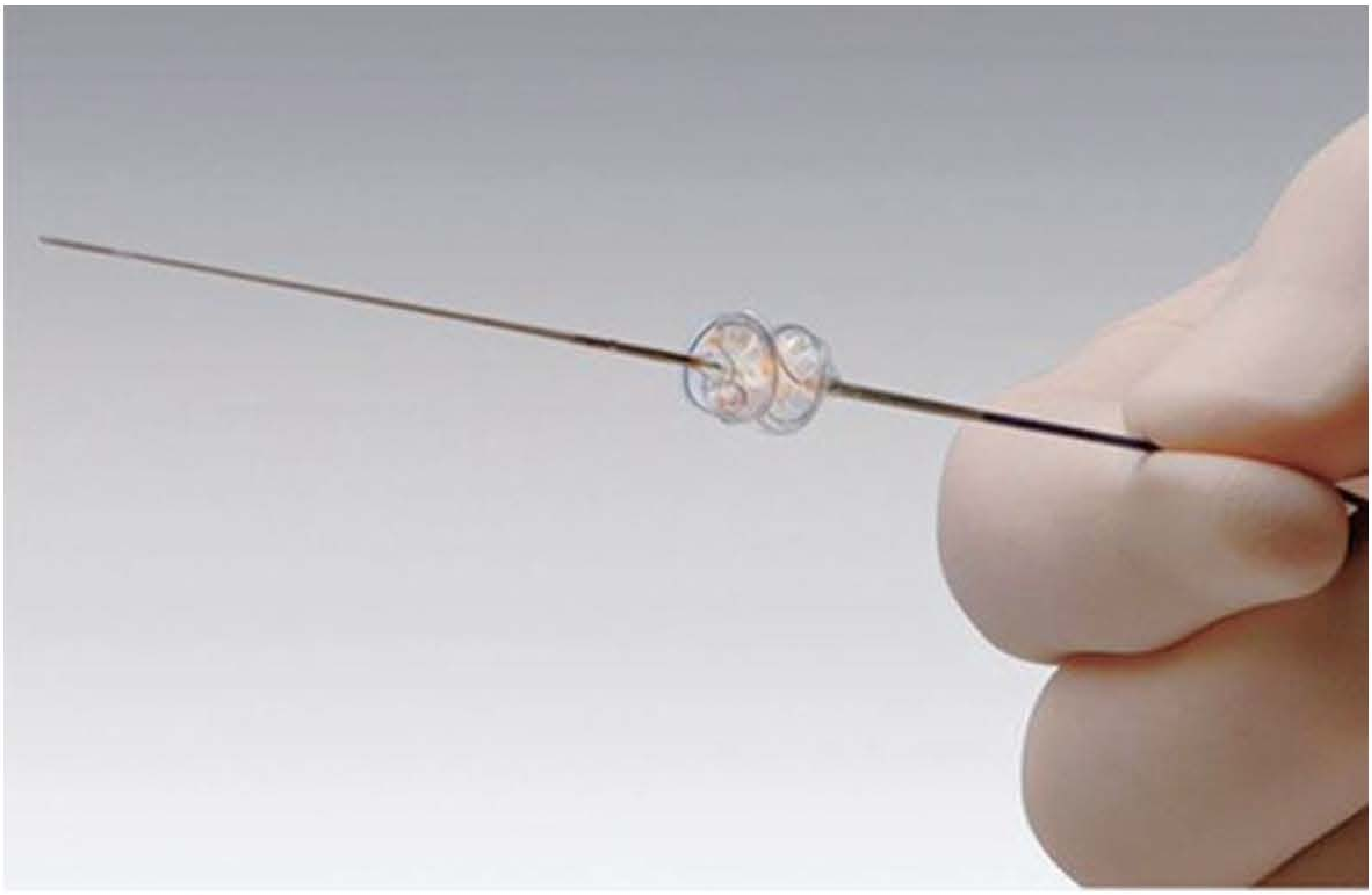

Figure 3.50 **The accordion device (PercSys, Palo Alto, CA, USA) after deployment.**

3.6.4.5. Selection of the Extracting Instrument

Choosing the proper extracting instruments may be essential for carrying out the ureteroscopic procedures in optimal conditions and for their success. The use of inadequate instruments may render the intervention impossible or can lead to iatrogenic lesions.

The selection depends on many factors, including the dimensions and localization of the stone, type of ureteroscope that is used, dimensions of the working channel, degree of deflection, degree of urinary tract dilatation, mucosal edema, and stone's degree of impaction. The extracting capacity of different types of probes and forceps has represented the object of recent studies. Ptashnyk et al. (2002) tested four different types of instruments on *ex vivo* models using pig kidneys and ureters. The ureteral lesions were evaluated by macroscopic examination. In order to extract a single 4 mm stone or an impacted 6 mm ureteral stone, the two-arm forceps ensured the quickest extraction with minimal ureteral damage. The helicoidal design led to the best results in the steinstrasse syndrome and, even though it required repeated insertions, it produced minimal ureteral lesions. The maximum incidence of ureteral lesions was determined by multi-spiral probes and tripod graspers. El-Gabry and Bagley (1999) tested different types of extractors *in vitro*. The helicoidal probes had a reduced efficiency in extracting small lithiasic fragments, while those with separate threads had a low success rate in extracting multiple stones.

3.6.5. Biopsy Instruments

A first category of instruments in this class is represented by biopsy brushes (Fig. 3.51). These are instruments that are fitted in the distal segment with a brush consisting of a variable number of threads arranged circularly. The desquamated cellular material is collected by applying these brushes at the site of the suspected lesions. The distal brush may be placed in the axis of the instrument or may form an angle with it for an easier application at the ureteral wall.

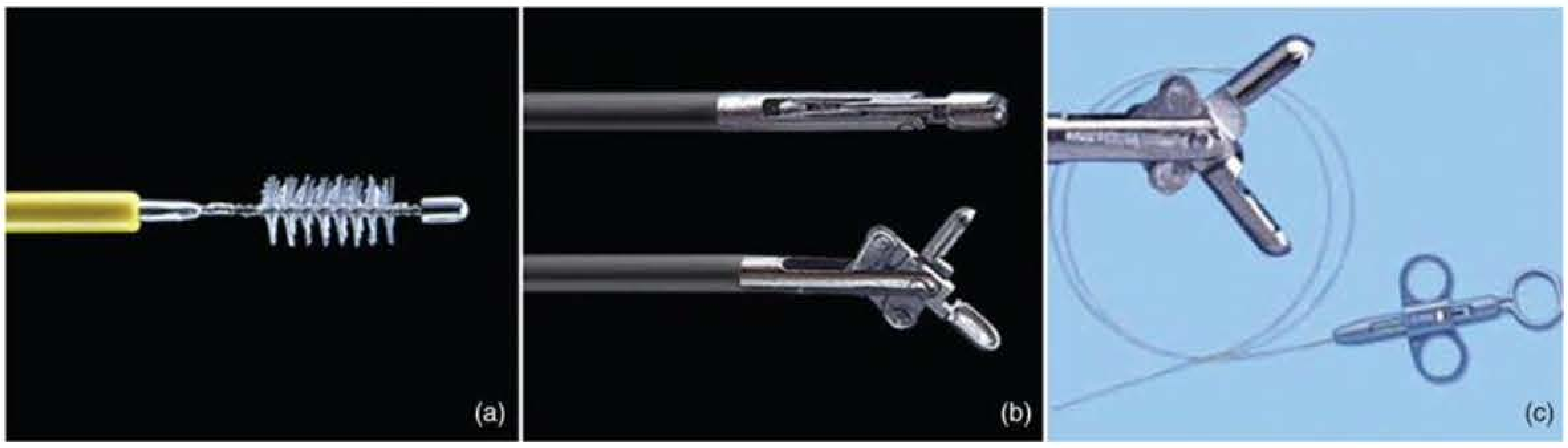

Figure 3.51 Instruments for collecting bioptic material.
(a) Biopsy brush (Cook Urological, Spencer, IN), (b) Cup Biopsy Forceps (Cook Urological, Spencer, IN), and (c) Flexible Biopsy Cup Forceps (Gyrus ACMI, Southborough, MA).

A second category is represented by biopsy forceps or clamps (Fig. 3.51, Table 3.4). These have a particular, excavated design of the two distal arms, intended for gathering as much tissue as possible. The opening mechanism of some models is similar to that of basket probes. The biopsy forceps have a caliber varying between 3 F and 5 F and can be used on rigid, semirigid, or flexible ureteroscopes.

A series of extracting instruments (forceps, basket probes) may be also used for bioptic purposes.

3.6.6. Cold-Knife Incision Instruments

Lasers such as the Ho:YAG are currently being used more and more frequently for incisions of the upper urinary tract. However, there is a large palette of accessory instruments for performing the so-called cold-knife incisions.

This category includes "scissors"-type knives, with the blade fitted on the external edge of the upper distal arm (Fig. 3.52), knives with an external sheath similar to that of basket probes and a mobile central blade, or incision blades (straight, half-moon, hook, etc.) attached on the mobile element of uretero-resectoscopes.

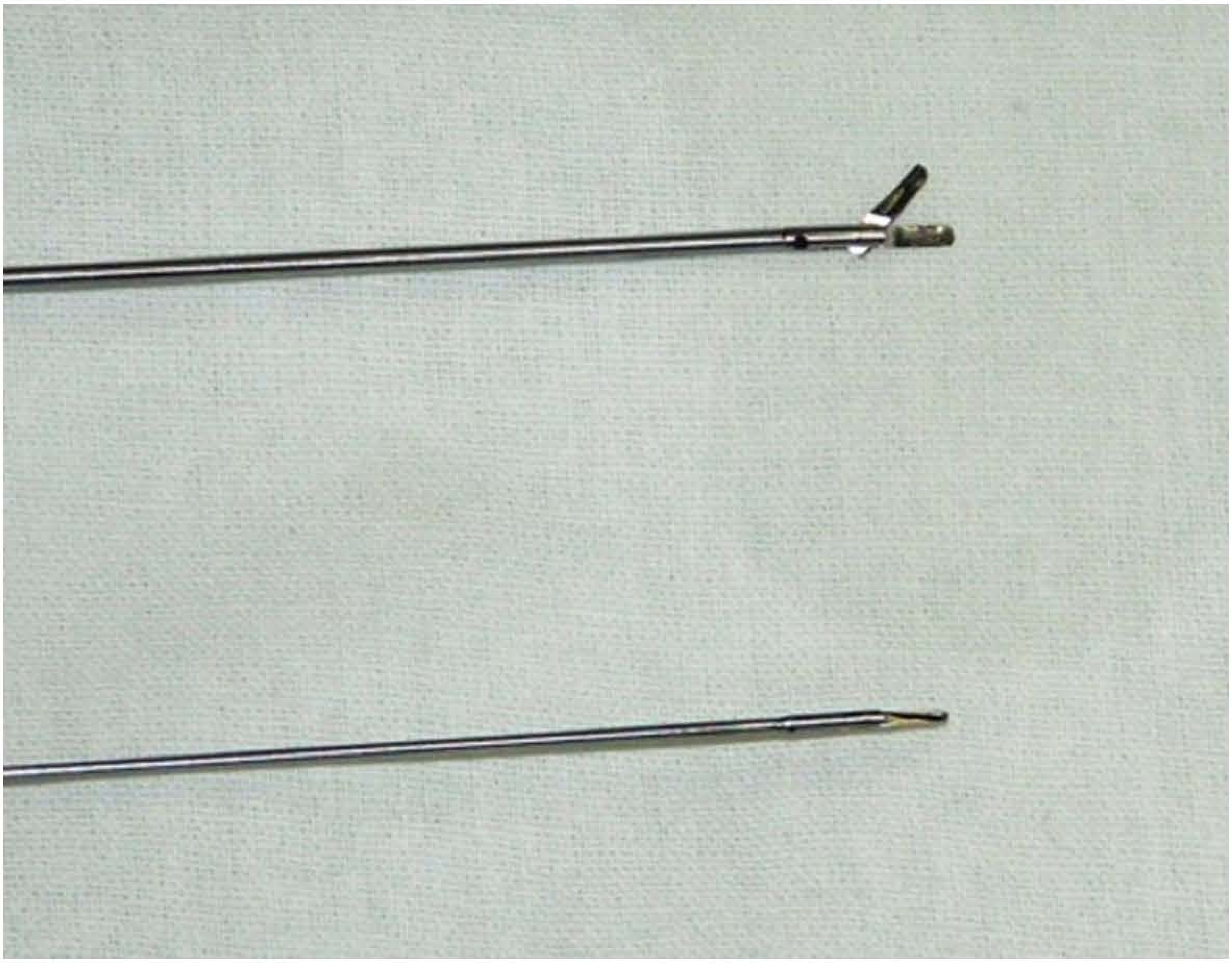

Figure 3.52 “Scissors”-type knives for upper urinary tract incisions.

The design of some of these incision instruments allows for sliding them on guidewires.

3.6.7. Endoluminal Ultrasound Instruments

A series of transducers having a caliber between 3 F and 6.2 F may be ascended through the ureteroscope’s working channel in order to perform endoluminal ultrasonography. These transducers have frequencies ranging between 12.5 MHz and 20 MHz, with a 1.5–2 cm penetrability. Endoluminal ultrasonography may be useful in assessing the presence of polar vessels, the depth of tumoral invasion, and the presence of submucous or extraureteral migrated lithiasic fragments, etc.

3.7. Ureteral stents

Placing an autostatic stent (Fig. 3.53) is necessary when there is a significant ureteral obstruction or after ureteroscopy, especially after ureteral orifice dilatations, after laborious interventions, or in case of associated upper urinary tract lesions. Also, ureteral stents may be placed as tutors after incisions of the upper urinary tract. Many types of endoprostheses with different dimensions, structures, and surfaces have been described in order to achieve these objectives.

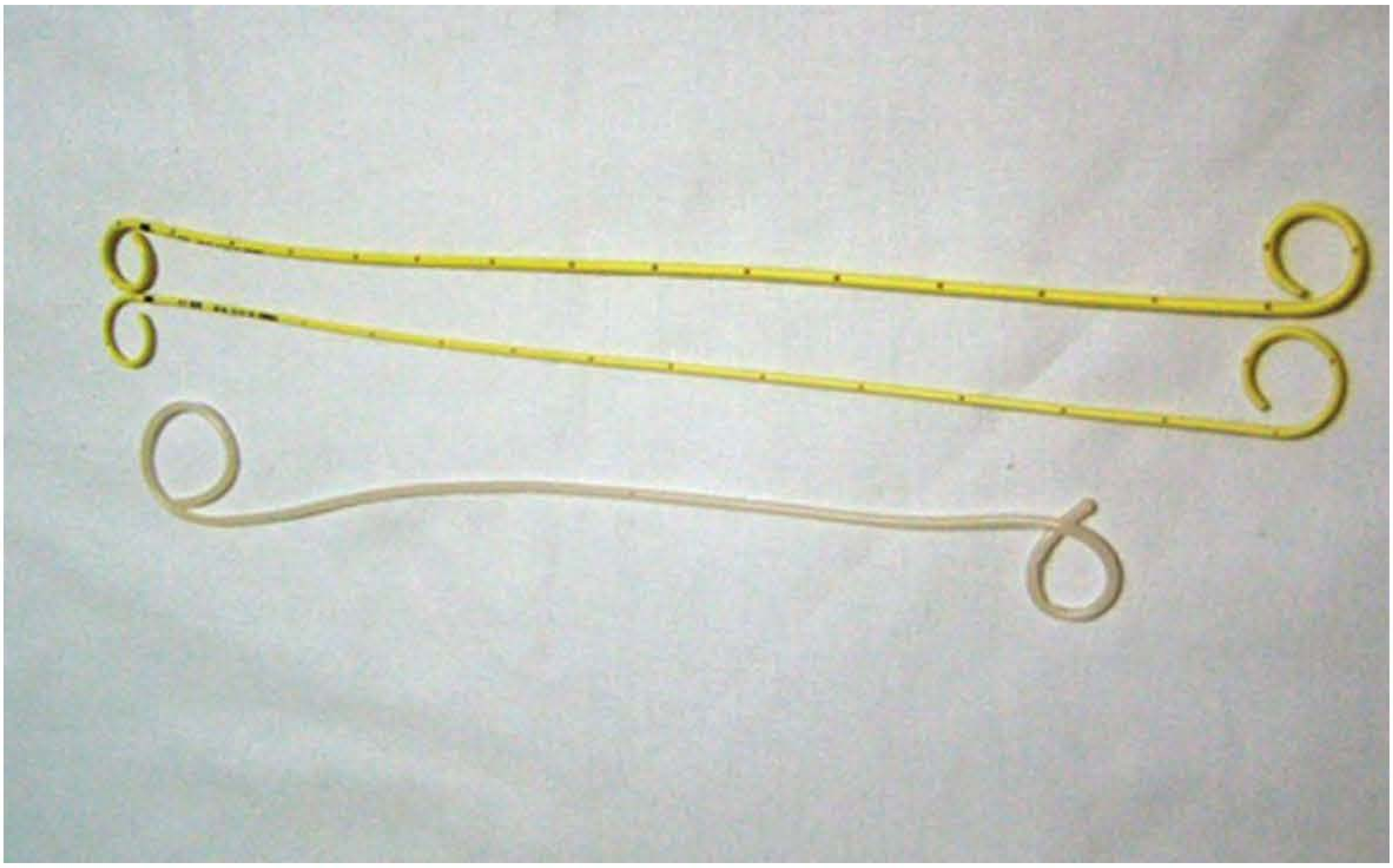

Figure 3.53 **Different types of autostatic ureteral catheters.**

3.7.1. Materials

Many types of materials have been used for making stents, including the following:

- polyurethane
- silicone
- C-Flex® (Cook Urological, Spencer, IN)
- Sof-Flex® (Cook Urological, Spencer, IN)
- Percuflex® (Boston Scientific, Natick, MA)

In a study performed by Mardis et al. (1993), stents made from different materials were compared, using numerous criteria: rigidity, resistance, biocompatibility, bioresistance, radiopacity, and friction surface. The results of the study showed that, ideally, the stents should have the following characteristics:

- resistance to deformation and tension
- resistance to migration
- biocompatibility and biodurability
- variable durometry
- reduced friction at the surface

The use of materials that are resistant to deformation and tension allow making stents with a large internal diameter without requiring a very large external diameter. Also, the stent may be fitted with multiple lateral orifices without affecting its structure. Resistance to migration is obtained as a result of the stent's "memory" maintaining its "J" shape at the ends once it is placed into position.

Because the stents must sometimes be maintained for long periods of time (weeks, months), they must be well tolerated by the organism (biocompatibility) and resistant to degradation (biodurability).

The stents must be radiopaque in order to allow the radiological localization and correct positioning. Also, a balance is necessary between malleability to ensure the patient's comfort, and firmness for placing them easily.

A series of models such as the LithoStent™ (Gyrus ACMI, Southborough, MA), InLay Optima®, and InLay® (Bard Urological, Covington, GA), etc., use thermosensitive materials. At room temperature, these are rigid enough to be easily inserted, but at the body's internal temperature, the material's consistency decreases, becoming soft and therefore better tolerated.

Recently, metallic JJ stents have started to be produced, such as the Resonance (Cook Urological, Spencer, IN) (Fig. 3.54). Used for the long-term drainage of patients with extrinsic ureteral strictures, this type of stent may be maintained for a period of up to 12 months, after which they must be replaced.

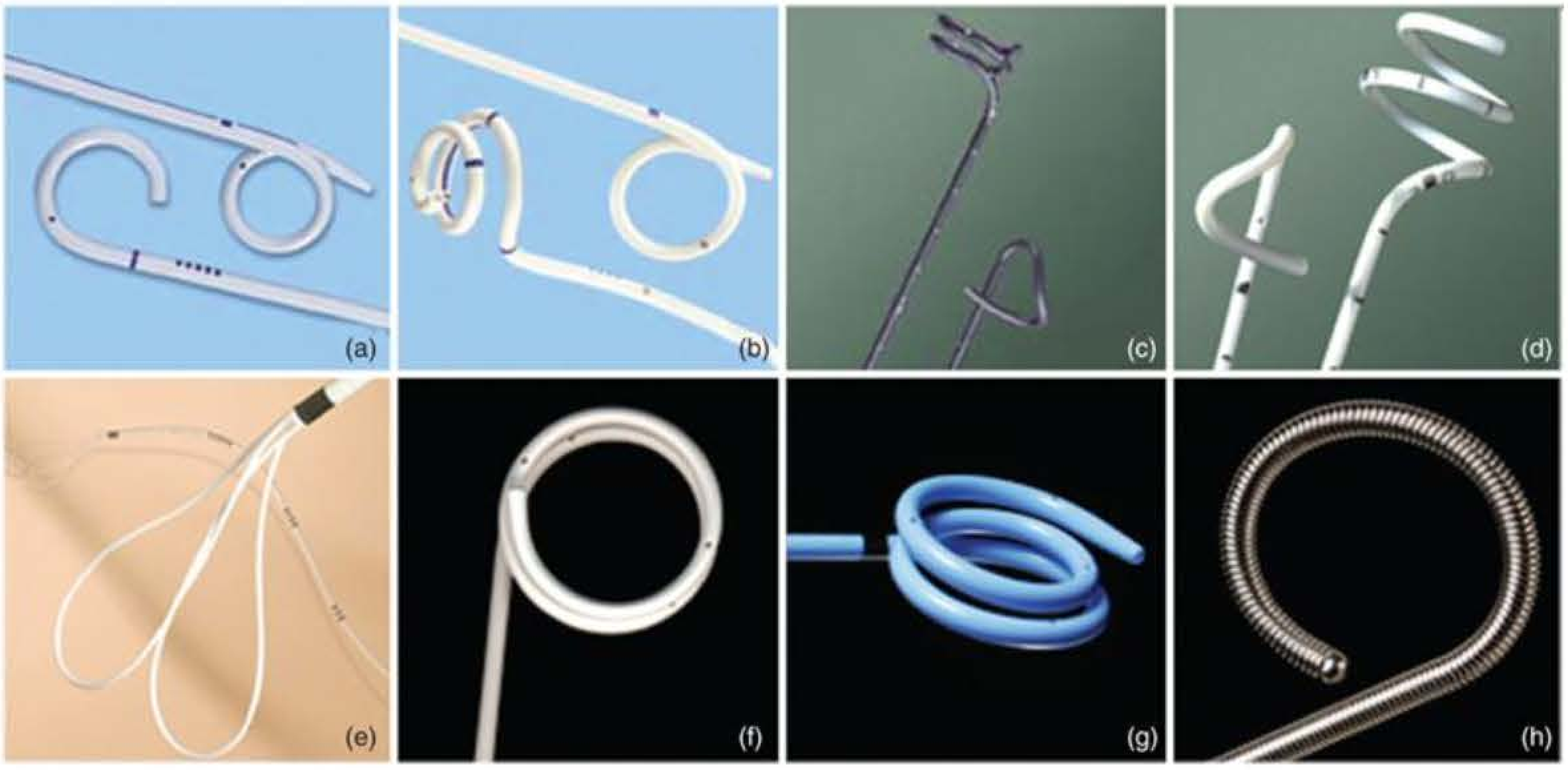

Figure 3.54 **Design features of different JJ catheter models.**
(a) Lubri-Flex® (Gyrus ACMI, Southborough, MA), (b) Quadra-Coil® (Gyrus ACMI, Southborough, MA), (c) Fluoro-4™ (Bard Urological, Covington, GA), (d) Figure 4 (Bard Urological, Covington, GA), (e) Polaris™ Loop (Boston Scientific, Natick, MA), (f) C-Flex Multi-Length (Cook Urological, Spencer, IN), (g) Endo-Sof™ Multi-Length (Cook Urological, Spencer, IN), and (h) Resonance (Cook Urological, Spencer, IN).

3.7.2. Stent Design and Dimensions

Ureteral stent design is conceived for ensuring the efficient drainage of the renal unit and its stability. In order to allow for an optimal drainage of the upper urinary tract, stents of different sizes have been made, with an external diameter ranging between 4.7 F and 18 F. In order to optimize drainage, most stents have orifices along their entire length.

Because drainage is not only intraluminal, but also around the stent, the LithoStent model (Gyrus ACMI, Southborough, MA) has a series of longitudinal notches on the external surface, having the role of facilitating this process.

Maintaining the stent in the correct position depends on the distal end's design, as well as on its proper length. Autostatic stents may have simple or double loops, and the length may vary between 12 cm and 32 cm (Table 3.6). In general, 24 cm stents are used in adults. However, choosing the length must be individualized according to the patient's height.

Table 3.6

Features of Different Autostatic Ureteral Catheter Models

Model	Manufacturer	Dimensions	Surface	Design
Quadra-Coil	Gyrus ACMI	4.5, 6, 7, 8.5 F, 22–28 cm	Hydrophilic	Multispiral
Double-J®	Gyrus ACMI	6, 7, 8.5 F,	Hydrophilic	Nonpermeable superior

		12–30 cm		end
Double-JII	Gyrus ACMI	6, 7 F, 22–28 cm	Hydrophilic	Nonpermeable superior end
LithoStent	Gyrus ACMI	7 F, 8–30 cm	Hydrophilic	Grooves on the external surface
Lubri-Flex	Gyrus ACMI	4.5, 6, 7, 8.5 F, 8–30 cm	Hydrophilic	Permeable superior end, 360° superior loop, nylon thread
Multi-Flex™	Gyrus ACMI	6, 7, 8.5 F, 12–30 cm	Hydrophilic	Permeable superior end
Soft-Curl™	Gyrus ACMI	6, 7 F, 22–28 cm	Hydrophilic	–
Figure 4	Bard Urological	5, 6, 7, 8 F, 23–30 cm	Silicone	3D loop design
Fluoro-4	Bard Urological	4.7, 6, 7, 8 F, 22–30 cm	Silicone	3D loop design
Bardex®	Bard Urological	4.7, 6, 7, 8 F, 16–30 cm	–	Nylon thread at the inferior end
InLay Optima	Bard Urological	4, 4.7, 6, 7, 8 F 14–32 cm	Hydrophilic	360° superior loop
InLay	Bard Urological	4.7, 6, 7, 8 F, 14–32 cm	Hydrophilic	360° superior loop
C-Flex surface AQ®	Cook Urological	5.6 F, 22–28 cm	Hydrophilic	360° superior loop
C-Flex Multi-Length	Cook Urological	3.7, 4.7, 5, 6, 7, 8, 22–28 F 21–23 cm	–	Multispiral
Endo-Sol™ surface AQ	Cook Urological	5, 6, 7, 8 F, 16–30 cm	Hydrophilic	360° superior loop
Endo-Sol Multi-Length surface AQ	Cook Urological	5, 6, 7, 8 F, 22–32 cm	Hydrophilic	Multispiral
Filiform Double Pigtail	Cook Urological	6, 7, 8.5 F, 20–30 cm	Silicone	360° superior loop
Sof-Flex surface AQ	Cook Urological	4.7, 6, 7, 8.2, 10 F, 20–30 cm	Hydrophilic	Nylon thread attached to the end
Resonance	Cook Urological	6 F, 20–30 cm	–	JJ metallic stent
Polaris Loop	Boston Scientific	5, 6, 7, 8 F, 10–30 cm	Hydrophilic	Closed inferior double loop
Polaris Ultra	Boston Scientific	5, 6, 7, 8 F, 24–26 cm	Hydrophilic	Nautilus™ inferior loop
Percuflex	Boston Scientific		Hydrophilic	Nylon thread at the inferior end
Contour VL™	Boston Scientific		Hydrophilic	Nautilus™ loops, multispiral, nylon thread at the end
Stretch™ VL	Boston Scientific		Hydrophilic	Nautilus™ loops, multispiral, nylon thread at the end

Stents with multiple loops or with variable dimensions, such as the models Quadra-Coil (Gyrus ACMI, Southborough, MA), or Endo-Sof Multi-Length and C-Flex Multi-Length (Cook Urological, Spencer, IN), may be adapted according to the length of the ureter, at the same time preventing their downward migration (Fig. 3.54).

In an attempt to reduce the complications associated with stents (bladder trigone irritation, vesicoureteral reflux, migration, etc.), new models with design particularities have started to be produced by different companies. This category includes the Polaris Loop (Boston Scientific, Natick, MA), with two loops closed inside the bladder in order to reduce the contact surface with the trigonal mucosa, or the Figure 4 and Fluoro-4 (Bard Urological, Covington, GA) with a tridimensional design of one or both loops, for a better autostatic fastening regardless of the anatomical particularities of the upper urinary tract (Fig. 3.54, Table 3.6).

Some stents have a thread at the distal end that allows their extraction without additional endoscopic maneuvers. The mono-J autostatic catheters have only one proximal loop in the pyelocaliceal system, and therefore they are not adequate for long-term drainage.

3.7.3. Stent Surface

In order to reduce friction during ascent, the ureteral endoprostheses have a silicone or a hydrophilic polymer layer at the surface (Table 3.6). This facilitates the insertion, the placing, and the extraction of the stents.

Modern polymers that are applied on the external and/or internal surface of JJ stents allow maintaining them for increasingly longer periods of time in the upper urinary tract. Therefore, models such as the InLay Optima (Bard Urological, Covington, GA), Endo-Sof AQ® (Cook Urological, Spencer, IN), Endo-Sof Multi-Length AQ (Cook Urological, Spencer, IN), Polaris Ultra (Boston Scientific, Natick, MA), etc., can be maintained for periods of 12 months, unlike the classic models that required extraction or replacement after a maximum 6 months.

3.7.4. Specific Ureteral Catheters

Specific stents have been conceived in order to ensure optimal results under special circumstances. Ureteral catheters of 5 F/30 cm may be useful to facilitate the guidewire's insertion at the ureteral orifice. These catheters may be used for urine sampling, as well as for performing retrograde ureteropyelography. Intraoperatively, they can facilitate ureter identification, preventing their accidental damage during open surgical interventions.

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Chapter

4.1. Generalities

In selected cases in which clinical, laboratory, and/or imagistic data are equivocal, establishing a correct diagnosis may require the endoscopic exploration of the upper urinary tract. Due to the complexity of the spatial distribution of the renal pelvis and the calyces, rigid or semirigid ureteroscopy does not allow for the exploration of the entire upper urinary tract in the vast majority of cases.

The use of flexible ureteroscopes has made possible, at least in theory, the minimally invasive approach of the upper urinary tract and its systematic exploration at any level, becoming not just an efficient therapeutic instrument, but also a very useful component of the investigation protocol.

Still, in our current phase of technological development, flexible ureteroscopes present a series of limitations regarding maneuverability and visibility. Although their utility in evaluating the pyelocaliceal system is indisputable, the balance is still in favor of rigid and semirigid endoscopes with regard to inspecting the ureter (especially its distal segment). Therefore, the standard diagnostic ureteroscopy protocol includes two stages: an initial stage for ureteral evaluation, which is performed with rigid instruments, and a second, pyelocaliceal stage, which uses flexible

4.2. Indications and contraindications

Ureteroscopy represents an extremely important part of the diagnostic armamentarium for the pathology of the upper urinary tract. However, endoscopic exploration is an invasive method, despite the reduction in aggressiveness of modern endoscopes as a result of technological progress. It is for this reason that the choice of performing ureteroscopy must be made based on clear criteria, when the other, less invasive explorations do not provide sufficient information for determining the diagnosis or therapeutic attitude (Geavlete et al., 2007a).

The indications for flexible diagnostic ureteroscopy can be systematized as follows (Geavlete et al., 2003):

- establishing the etiology of a lacunar image at the level of the upper urinary tract, detected by imaging exams
- determining the etiology of hematuria originating in the upper urinary tract, which cannot be diagnosed through other methods
- localizing the source of modifications of the urinary cytological tests in patients with normal cystoscopy
- follow-up of patients with conservatively treated upper urinary tract urothelial tumors, within the postoperative protocol
- determining the etiology of an obstacle at the level of the upper urinary tract

4.2.1. Lacunar Images at the Level of the Upper Urinary Tract

Ureteroscopy may allow the determination of the nature of upper urinary tract lesions: malignant (transitional cell carcinoma, etc.) (Fig. 4.1) or benign (calculi, polyps, hemangiomas, tuberculous lesions, cellular detritus, or blood clots, etc.) (Fig. 4.2).

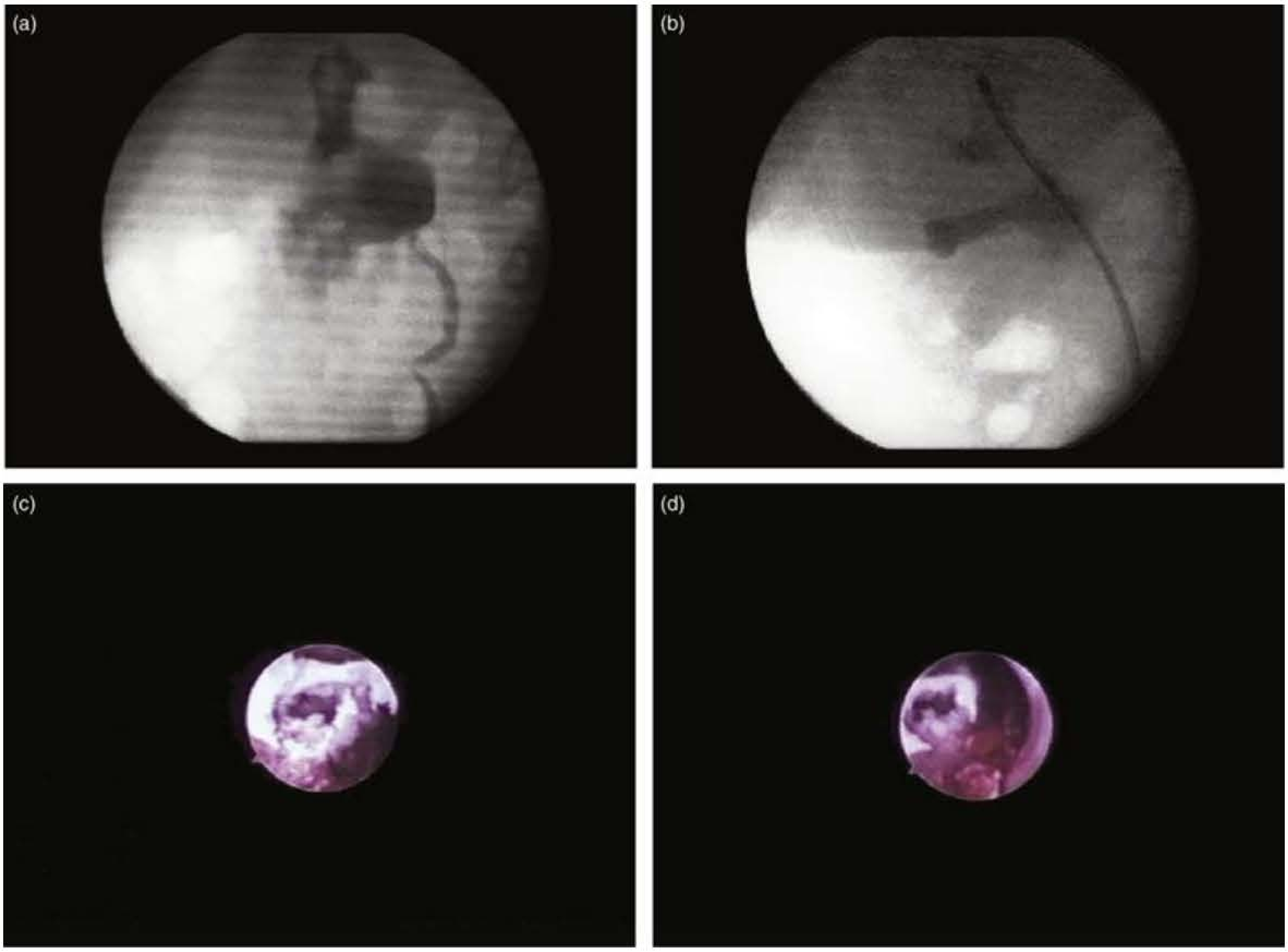


Figure 4.1 Diagnostic ureteroscopy in a patient with upper caliceal lacunar image.
Retrograde pyelography highlighting the lacunar image at the level of the upper calyx (a), flexible ureteroscopic inspection of the upper calyx (intraoperative fluoroscopy) (b), upper caliceal urothelial carcinoma (c, d).

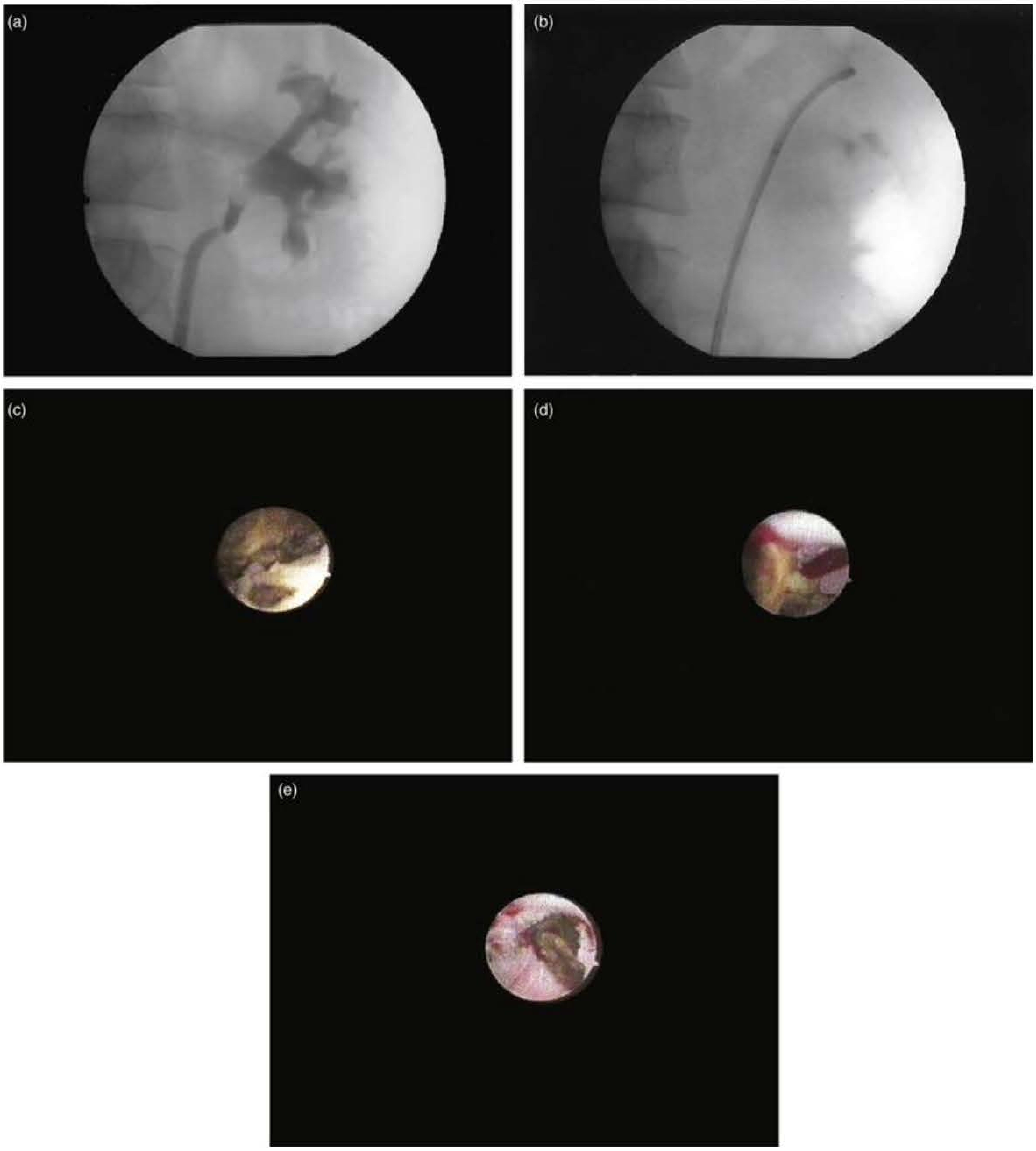


Figure 4.2 **Diagnostic ureteroscopy in a patient with upper caliceal lacunar image.** Retrograde pyelography highlighting the lacunar image at the level of the upper calyx (a), flexible ureteroscopic inspection of the upper calyx (intraoperative fluoroscopy) (b), old clot at the upper caliceal level (c), extracting the upper caliceal clot (d), normal aspect of the caliceal mucosa under the clot fragments (e).

The ureteroscopic evaluation must not be stopped after identifying a lesion, but must continue with the systematic exploration of the entire upper urinary tract (Fig. 4.3).

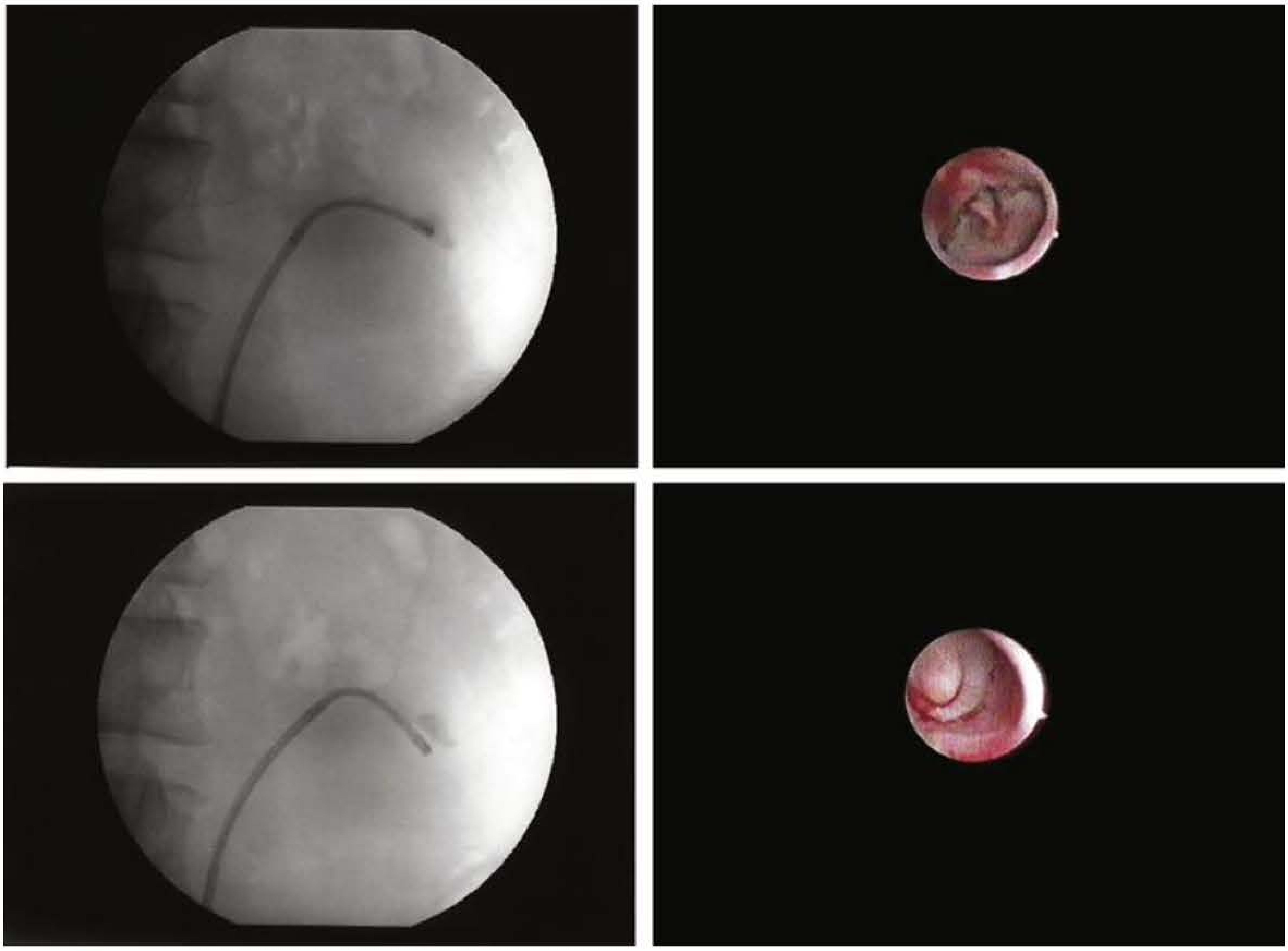


Figure 4.3 **The systematic inspection of the other caliceal groups, without detecting tumoral masses.**

Evaluation is performed by gradually using the diagnostic methods, from the least invasive to the more aggressive ones.

Anamnesis may provide clues that can guide the diagnosis:

- a history of lithiasis or of bladder tumors may guide the diagnosis toward the same type of conditions
- in patients with a history of diabetes, recurrent urinary infections, abuse of analgesics or blood disorders, the filling defect may be more frequently determined by papillary necrosis or by a blood clot
- uretero-enteric fistulas may be suspected in patients with inflammatory bowel diseases
- recurrent *Escherichia coli* infections may be associated with malakoplakia
- pneumaturia may appear due to a communication between the colon and the upper or, more frequently, lower urinary tract

Complete urine analysis is also a mandatory component of the diagnostic protocol:

- pH over 6.5 is frequently associated with uric lithiasis
- in hematuria, the filling defect may be caused by a clot
- urinary cytology is useful for detecting urothelial tumors, but is encumbered by a significant rate of false positive or negative results, depending on the tumor grade
- the presence of aerobic and anaerobic germs detected in the urine culture raises the suspicion of a uretero-intestinal fistula

The next step in evaluating a filling defect discovered by intravenous urography (IVU) is comprised of other imaging explorations (CT, MRI, etc.).

If a diagnosis cannot be established following these exams (Table 4.1), the next step is represented by ureteropyelography and ureteroscopy.

Table 4.1

Upper Urinary Tract Filling Defects: Differential Diagnosis

Common entities

Tumors	Transitional cell carcinoma
Lithiasis	Uric acid calculus
Blood clot	Trauma/tumors (Fig. 4.4)
Air	Iatrogenic (RUP)
Infection/inflammation	Papillary necrosis
	Ball of fungi
Rare causes	
Tumors	Leukemic infiltrate
	Angiolipoma
	Multiple myeloma
	Lymphoma
	Wilms’ tumor
	Cysts
	Polyps (Fig. 4.5)
	Squamous cell cancer
	Adenocarcinoma
	Leukoplasia
	Amyloidosis
	Sarcoma
	Connective tissue tumors
	Metastatic tumors
Urinary lithiasis	Soft (matrix)
	Xanthine
Blood clot	Coagulopathy
	Nephritis
	Anticoagulants
Air	Enteric fistulas
Congenital	Vessels
	Ectopic papillae
	Hypertrophic papillae (Figs 4.6 and 4.7)
Vascular	Renal artery aneurysm
	Vascular impressions (vessels that cross the renal pelvis, lower renal pole vessel, ovarian vein)
	Arteriovenous fistulas
Infection/inflammation	Cystic pyelitis
	Cystic ureteritis
	Tuberculosis
	Malakoplakia
	Helminths
	Fistula
Foreign bodies	Iatrogenic (Fig. 4.8)

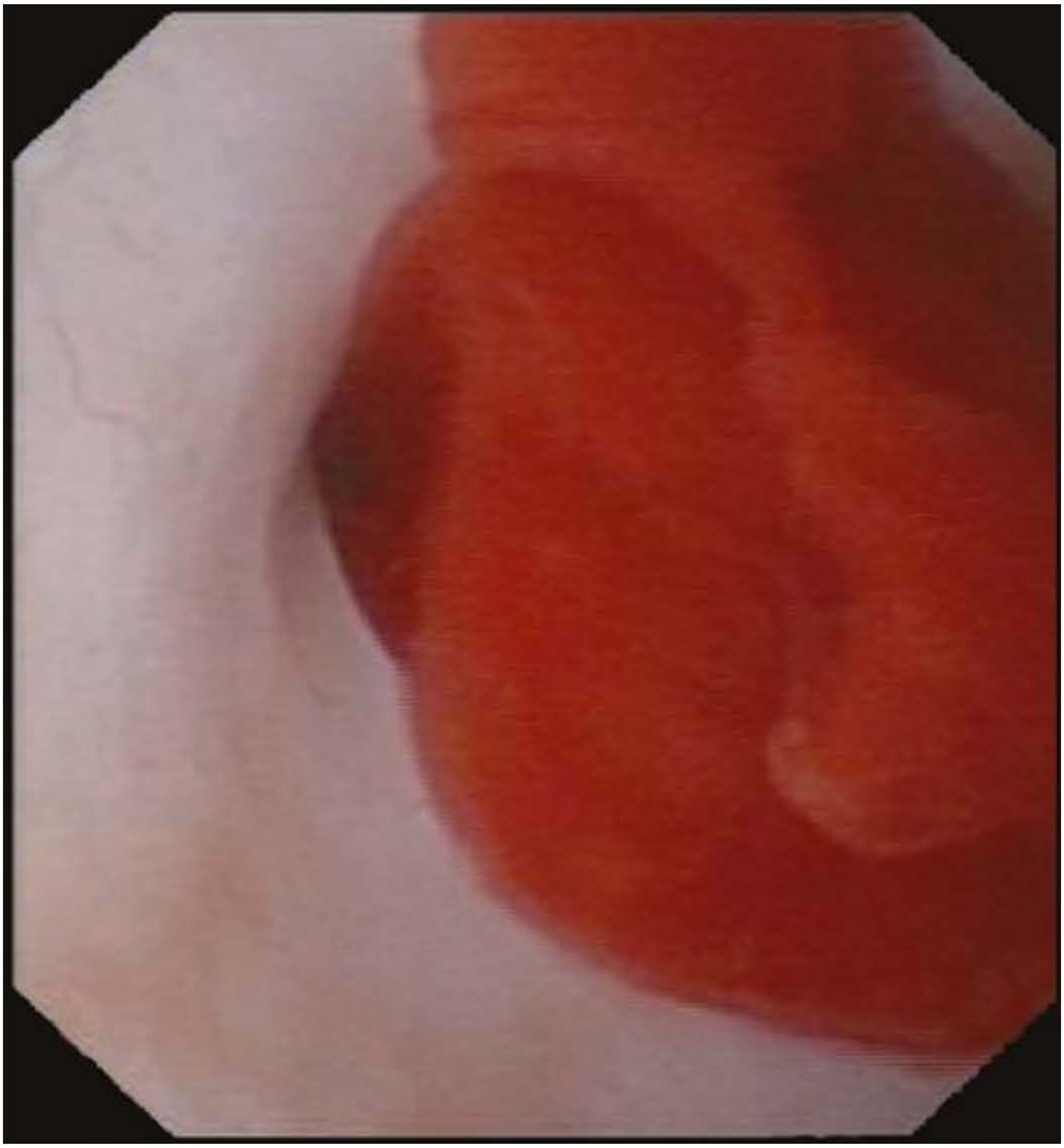


Figure 4.4 **Upper calyx clot determining a lacunar image on pyelography.**

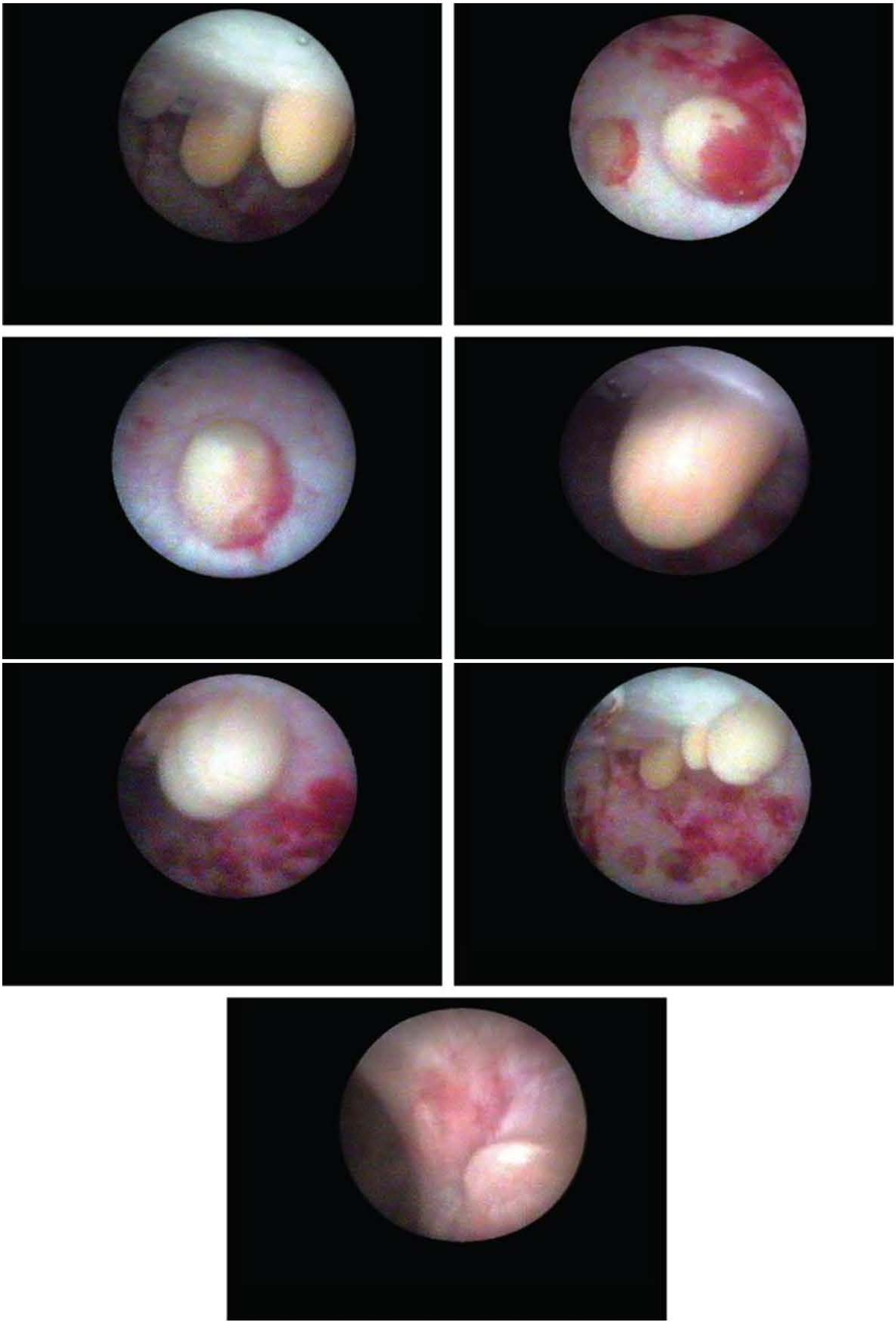


Figure 4.5 Pseudotumoral polypoid masses at the renal pelvis level (retrograde semirigid ureteroscopy).

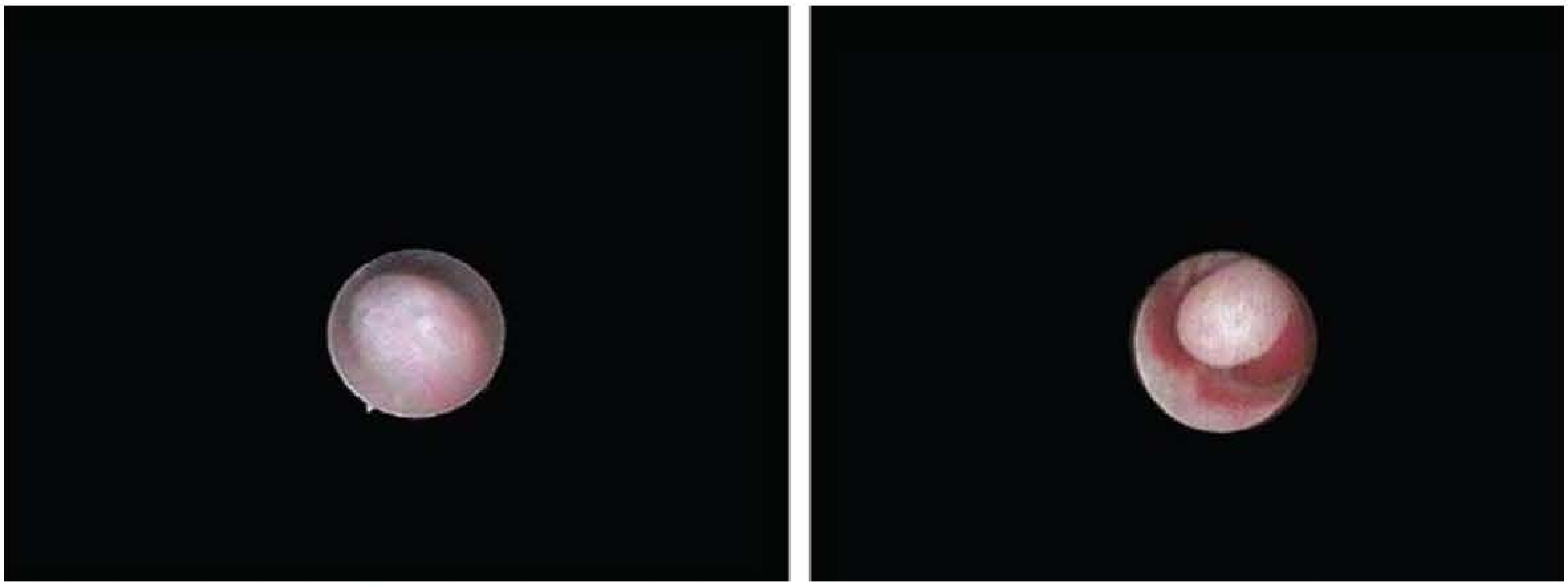


Figure 4.6 Endoscopic aspects of hypertrophic caliceal papillae.

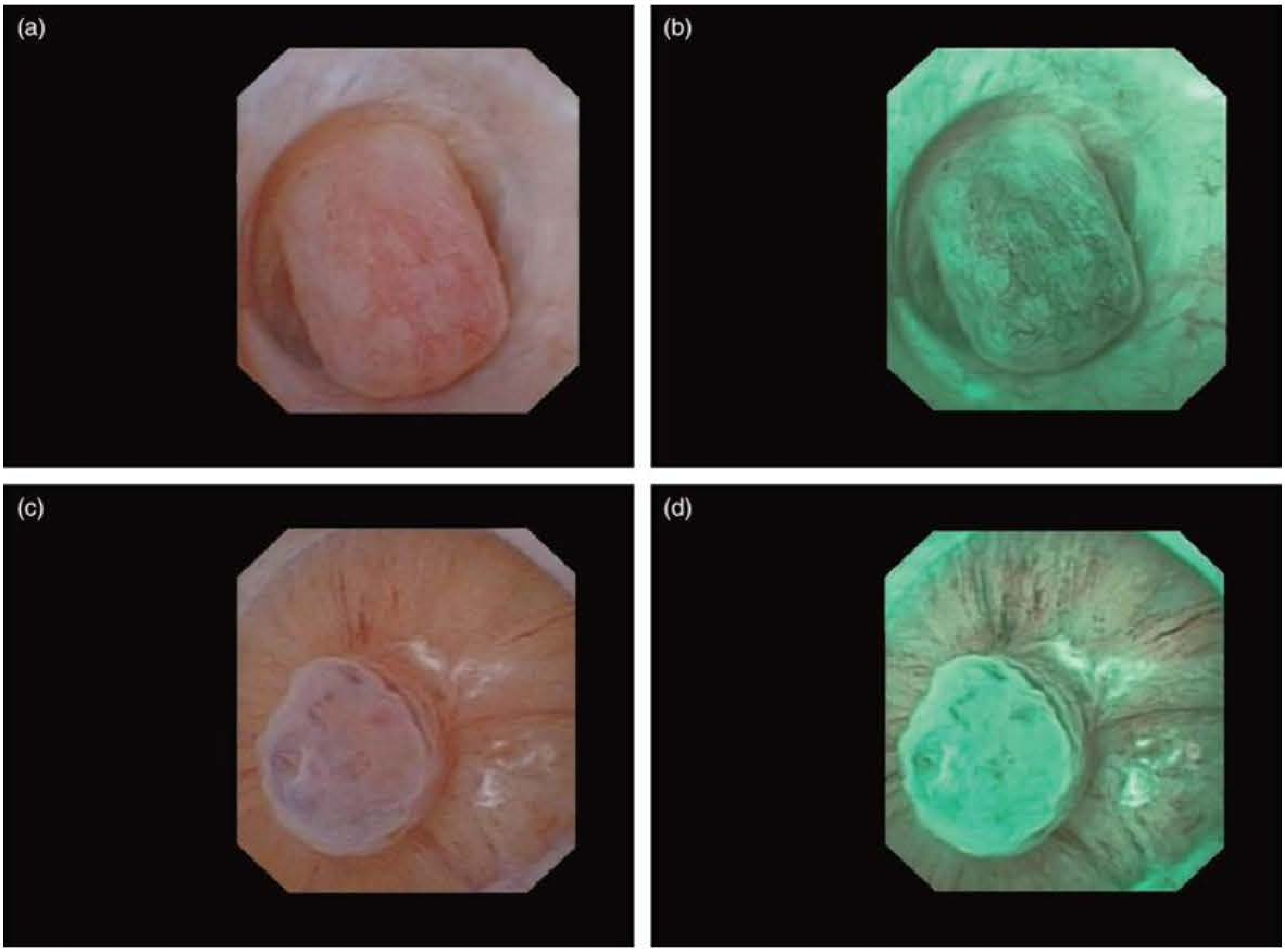


Figure 4.7 Hypertrophic caliceal papillae, without tumoral characteristics in white light (a, c) or NBI (b, d).

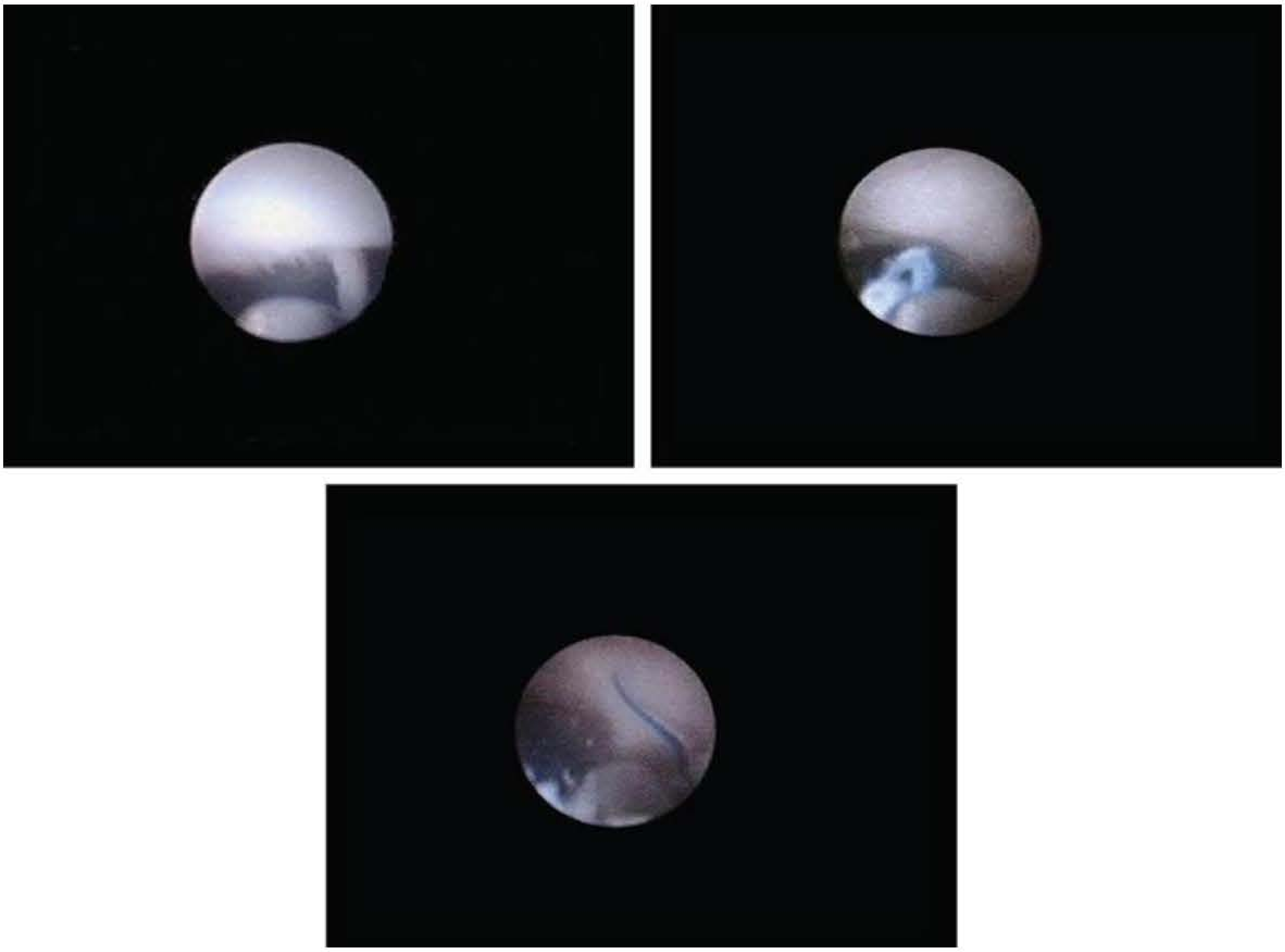


Figure 4.8 **Unabsorbed sutures at the pyelocaliceal level in a patient with a history of pyeloplasty.**

Any lacunar image with an origin not determined through imaging investigations must be explored ureteroscopically (Fig. 4.9).

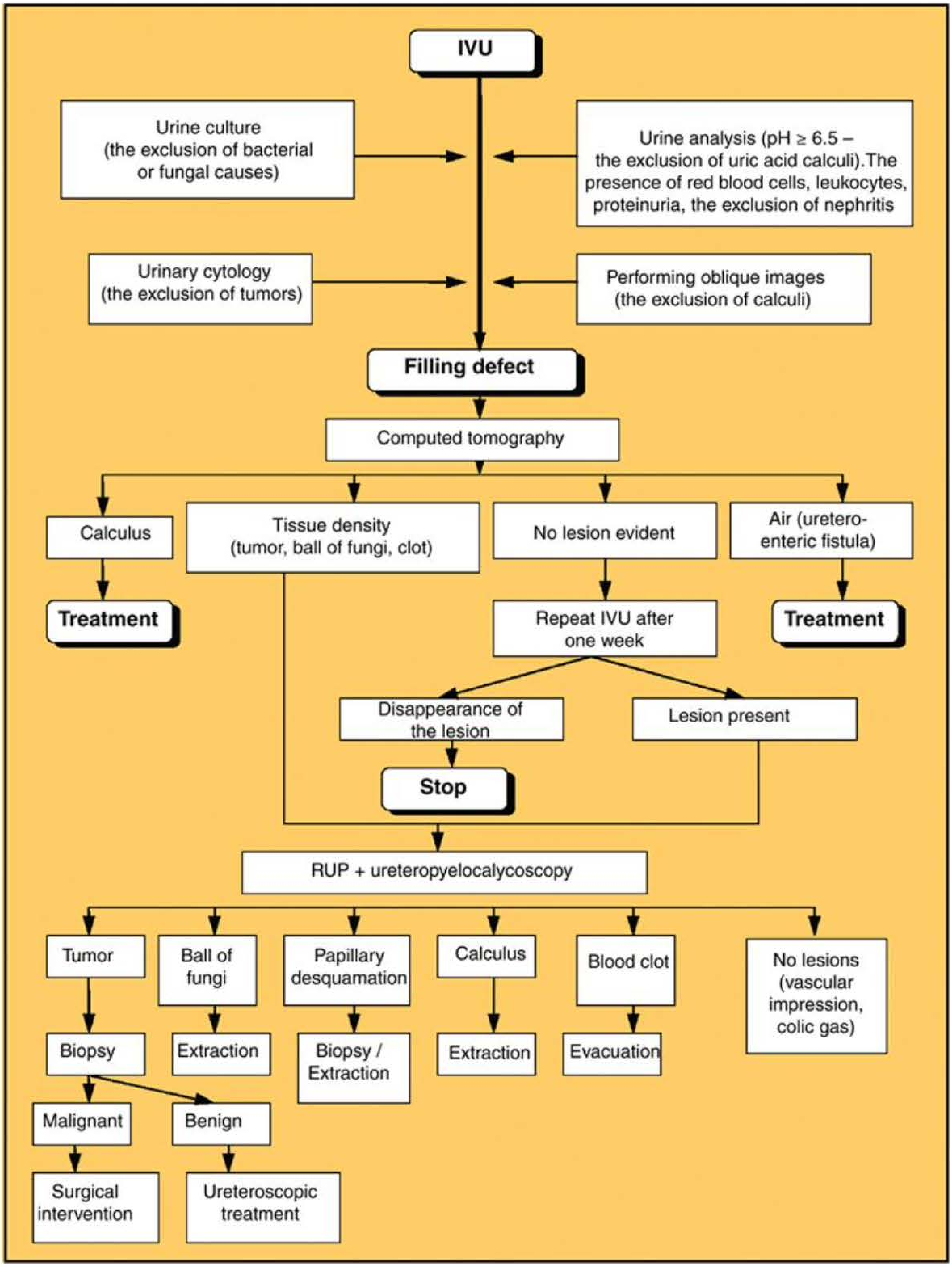

IVU
Urine culture (the exclusion of bacterial or fungal causes)
Urine analysis (pH ≥ 6.5 – the exclusion of uric acid calculi).The presence of red blood cells, leukocytes, proteinuria, the exclusion of nephritis
Urinary cytology (the exclusion of tumors)
Performing oblique images (the exclusion of calculi)
Filling defect
Computed tomography
Calculus
Tissue density (tumor, ball of fungi, clot)
No lesion evident
Air (uretero-enteric fistula)
Treatment
Repeat IVU after one week
Treatment
Disappearance of the lesion
Lesion present
Stop
RUP + ureteropyelocalycoscopy
Tumor
Ball of fungi
Papillary desquamation
Calculus
Blood clot
No lesions (vascular impression, colic gas)
Biopsy
Extraction
Biopsy / Extraction
Extraction
Evacuation
Malignant
Benign
Surgical intervention
Ureteroscopic treatment

Figure 4.9 **Management of upper urinary tract filling defects.** Source: Modified after Resnick.

Endoscopic exploration can be included in the diagnostic algorithm of patients with upper urinary tract urothelial tumors, allowing visualization and evaluation of tumor dimensions, as well as harvesting of tissue for histopathological confirmation. Uretero-pyeloscopic exploration associated with tissue biopsy is a standard investigation for all patients with upper urinary tract lesions, excepting those in whom ultrasonography is suggestive of lithiasic disease (Bagley and Rivas, 1990).

4.2.2. Unilateral Hematuria

The endoscopic approach may contribute to the establishment of the etiological diagnosis of hematuria originating in the upper urinary tract (Table 4.2).

Table 4.2

Causes of Unilateral Hematuria

Urinary lithiasis	
Vascular causes	Hemangiomas
	Arteriovenous aneurysm
	Venous ectasia
Infection/inflammation	Nonspecific infections
	Tuberculosis
	Papillary necrosis
Reno-ureteral trauma	
Tumors	Transitional cell carcinoma Multiple myeloma
	Lymphoma
	Wilms' tumor
	Cysts
	Squamous cell cancer
	Adenocarcinoma
	Sarcoma
	Connective tissue tumors
	Metastatic tumors
Systemic causes	Coagulopathy
	Hemoglobinopathies
	Nephritis
	Anticoagulants

For patients with macroscopic hematuria, the investigation protocol includes anamnesis and a thorough physical exam, laboratory exams (urinary cytology, determining proteinuria, coagulation tests), and imaging exams (IVU, CT, arteriography), as well as endoscopic evaluation of the urinary tract (Fig. 4.10).

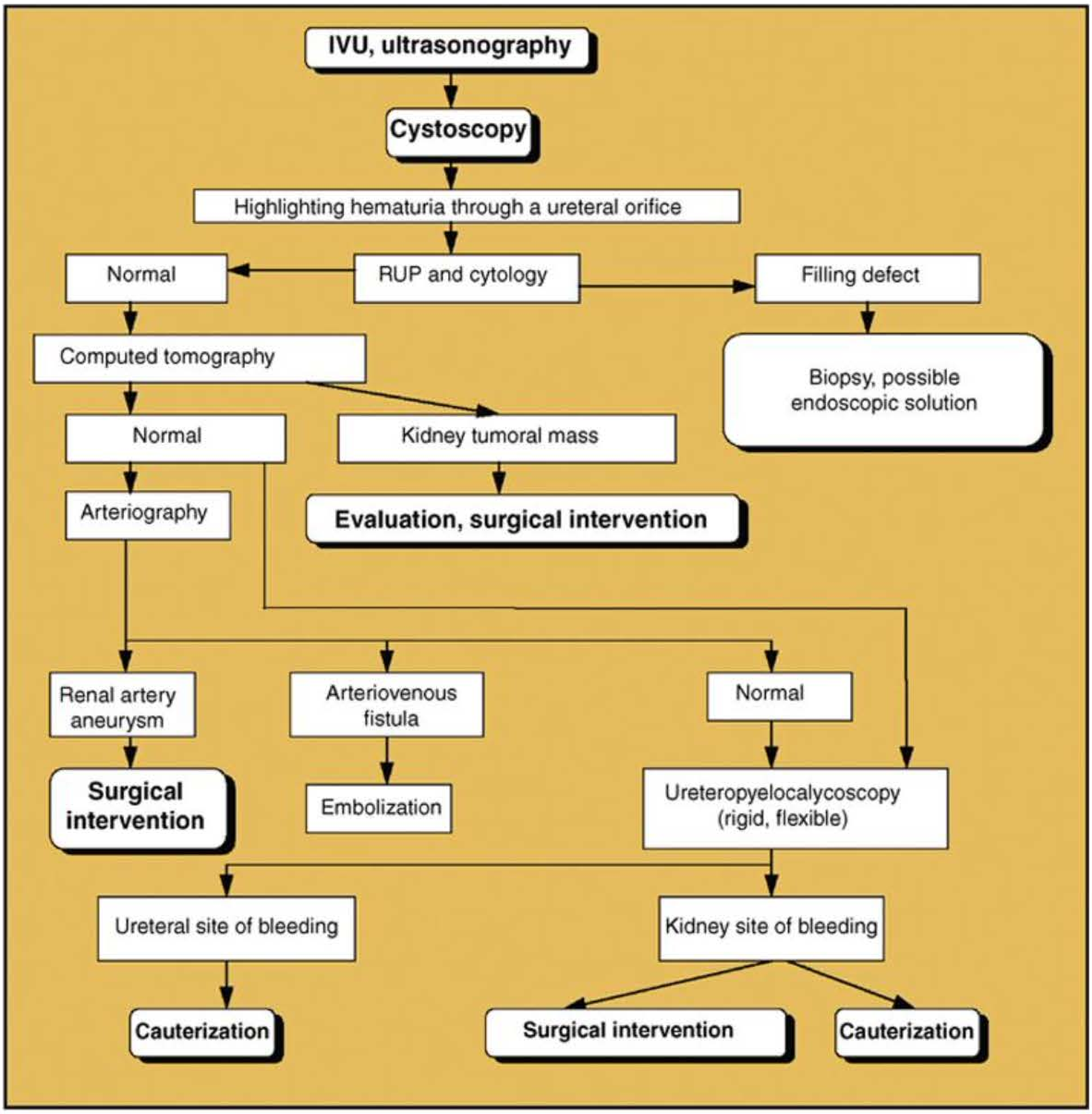

IVU, ultrasonography
Cystoscopy
Highlighting hematuria through a ureteral orifice
Normal
RUP and cytology
Filling defect
Computed tomography
Biopsy, possible endoscopic solution
Normal
Kidney tumoral mass
Arteriography
Evaluation, surgical intervention
Renal artery aneurysm
Arteriovenous fistula
Normal
Surgical intervention
Embolization
Ureteropyelocalycoscopy (rigid, flexible)
Ureteral site of bleeding
Kidney site of bleeding
Cauterization
Surgical intervention
Cauterization

Figure 4.10 **Management of patients with unilateral hematuria.**

The physical exam can detect cutaneous or oral mucosal hemangiomas, which may indicate the presence of similar lesions at the kidney level.

The examination of the morphology of red blood cells in the urine may differentiate bleeding caused by glomerular affections (red blood cells with modified morphology) from an anatomical lesion (cells with normal morphology). In 1987, Tomita described five different types of red blood cells indicating the glomerular or nonglomerular source of bleeding. This test has a good accuracy, studies showing a 73–90% sensitivity and a 60–98% specificity.

In patients with unilateral hematuria of undetermined cause, detailed analysis of urinary proteins may have a diagnostic role. Thus, a nonglomerular source of hematuria determines an increase in high molecular weight urinary proteins. When urinary albumin is greater than 100 mg/L, it is recommended to determine alpha2-macroglobulin from the second morning urine. If this is also increased (alpha2-macroglobulin/albumin > 2/100), the bleeding source is probably nonglomerular, postrenal.

Besides the previously described tests, the diagnostic protocol also includes ultrasonography, IVU, and cystoscopy. Urography must clearly visualize all of the calyces and the entire length of the ureter, which most often requires performing multiple radiological imagings and repositioning of the patient. If satisfactory images are not obtained at urography, retrograde ureteropyelography, a more invasive diagnostic method, may be performed.

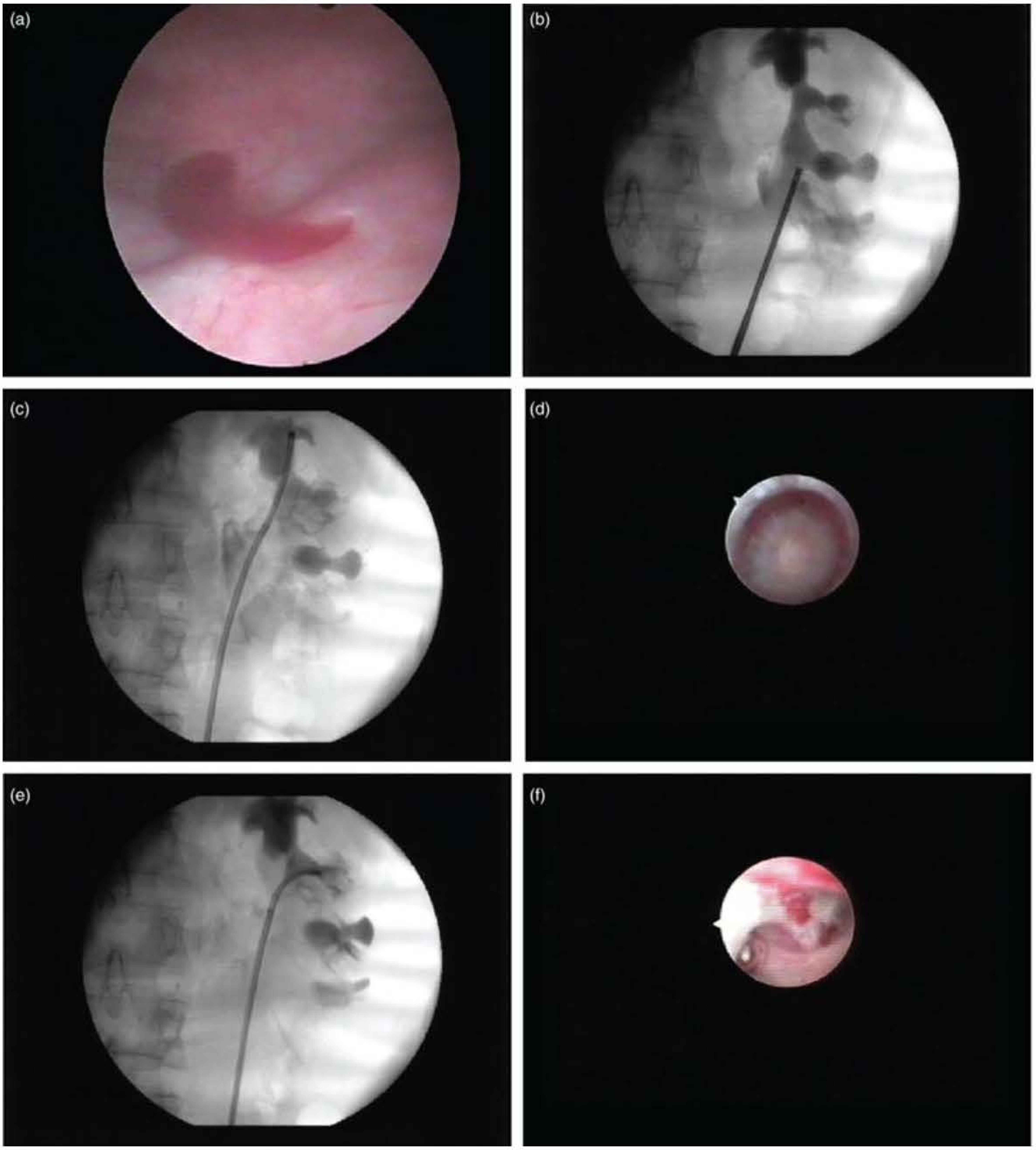
If urography and retrograde ureteropyelography do not detect a cause for hematuria (filling defects, calculi, kidney tumors) and bleeding through a ureteral orifice is visualized on cystoscopy, a CT exam is indicated. Some authors recommend CT before retrograde ureteropyelography.

If these explorations do not provide significant data, renal arteriography may be performed in the next diagnostic step, which may detect an arteriovenous malformation or another vascular affection. This method sometimes resolves the respective cause by embolization. There is no unanimously accepted indication for performing this type of paraclinical exam.

Some authors recommend performing angiography only if there is a history of punctures, surgical interventions, trauma, or kidney tumors (Ankem et al., 2005).

Angiography may be replaced by the more modern angio-MRI.

The last diagnostic step is ureteroscopy (Fig. 4.11). It is recommended to perform the endoscopic exploration in case of active hematuria because the detection of lesions is difficult, if not impossible, after its cessation.



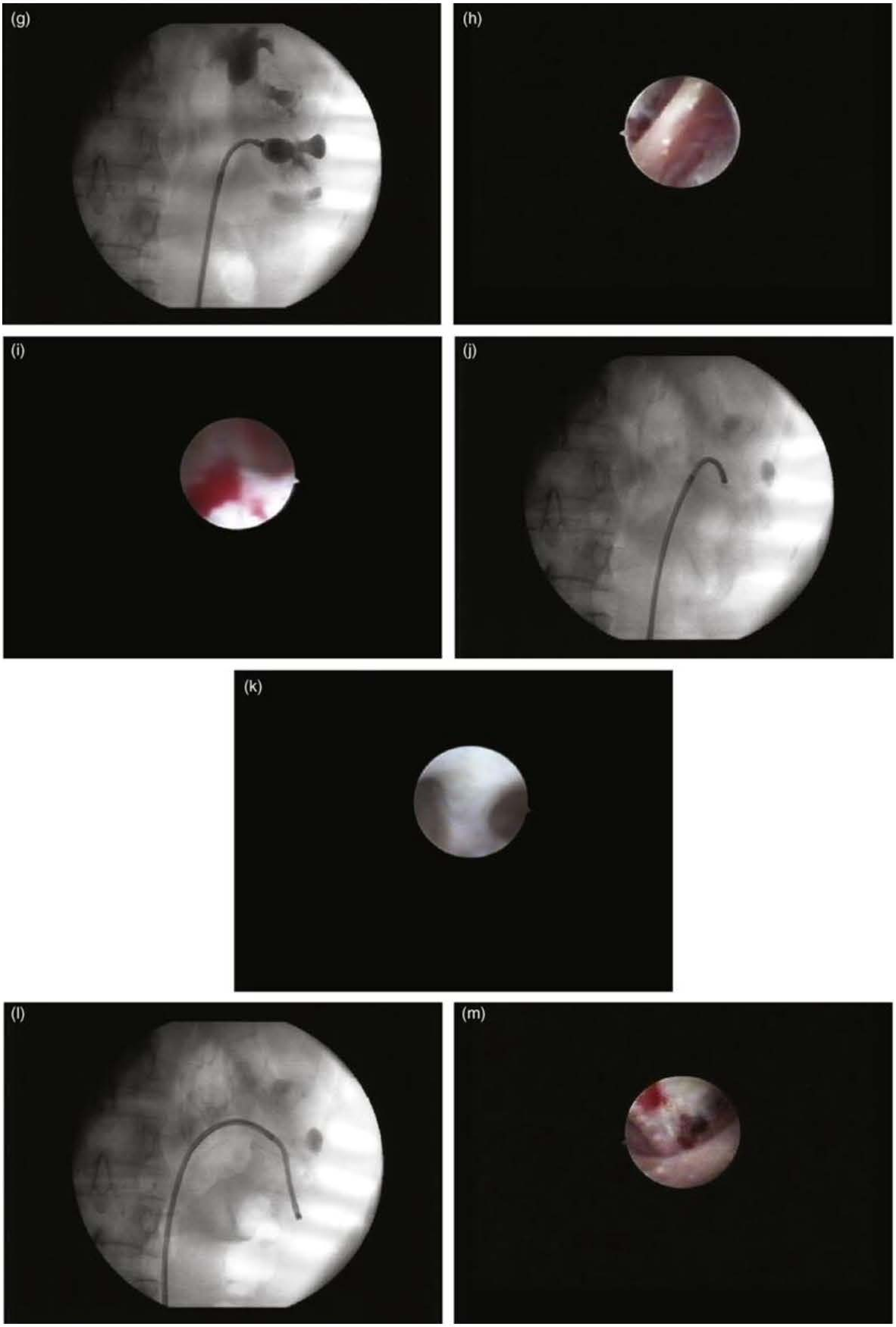


Figure 4.11 **Flexible ureteroscopic exploration in a patient with unilateral hematuria.**
Bleeding at the level of the left ureteral orifice (a), inspection with the help of the semirigid ureteroscope up to the level of the left renal pelvis (intraoperatory fluoroscopy) (b), normal aspect at the flexible ureteroscopic inspection

of the upper calyx (c, d), hemorrhagic vascular lesions at the level of the secondary upper calyx papilla (e, f), hemorrhagic vascular lesions at the level of the middle calyx papilla (g, h), blood clot at the level of the middle caliceal infundibulum (i), flexible ureteroscopic approach of the lower caliceal group (j, k), vascular lesions at the level of the lower calyx papilla (l, m).

In the etiological diagnosis of hematuria originating in the upper urinary tract, it is essential to determine the malignant or benign nature of the cause. This is even more important due to the fact that for well-differentiated upper urinary tract urothelial carcinomas, the cytological exam can provide false negative results in up to 80% of cases (McCarron et al., 1983).

A cause of chronic unilateral hematuria, especially in young patients, may be represented by renal hemangiomas (Dooley and Pietrow, 2004) (Fig. 4.12).

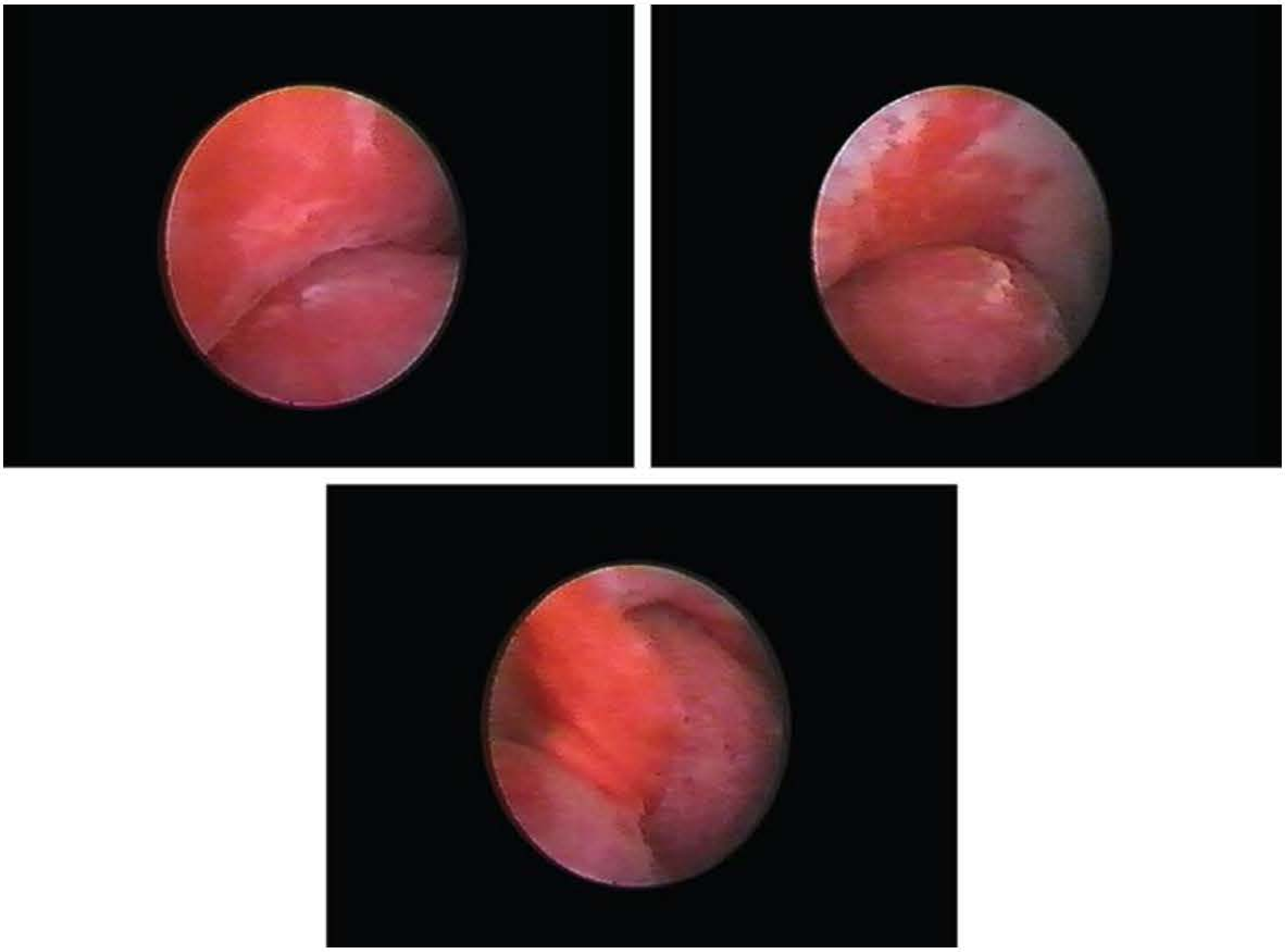


Figure 4.12 **Bleeding papillary hemangioma.**

These are solitary or multiple venous malformations, localized most often at the level of the papilla. Hematuria determined by this condition is most frequently spontaneous and intermittent, being triggered by the thrombosis and infarction of the hemangioma or by the erosion of the mucosa on its surface (Dooley and Pietrow, 2004).

In most cases, vascular lesions such as ruptured hemangiomas or venous ectasias can only be detected endoscopically (Bagley and Allen, 1990; Nakada et al., 1997).

Other causes of unilateral total hematuria are represented by calculi (Fig. 4.13), tumors (Figs 4.14 and 4.15), stenoses, specific ureteral or pyelocaliceal inflammatory lesions (tuberculosis) (Fig. 4.16), or nonspecific ones (Fig. 4.17).

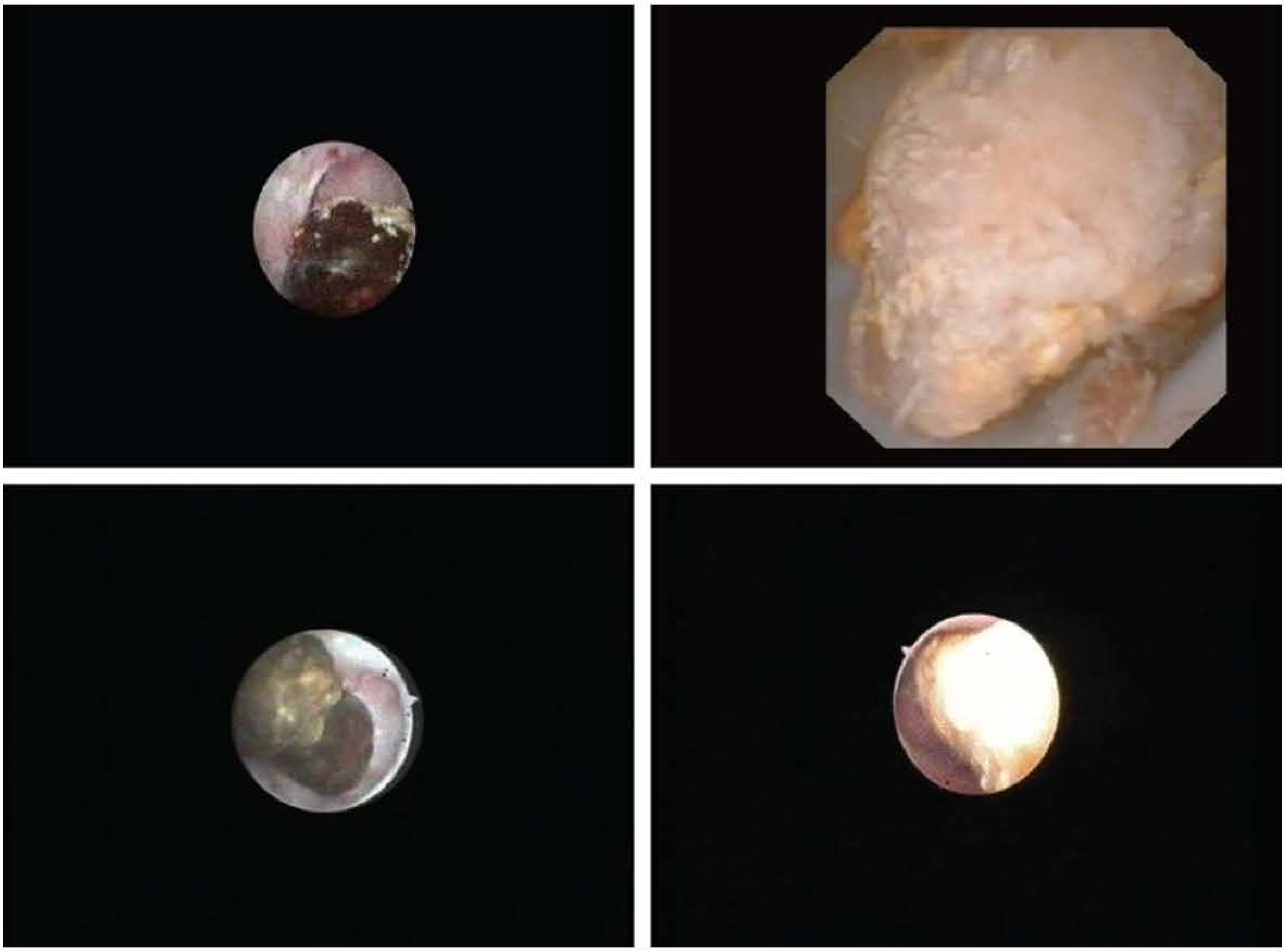


Figure 4.13 **Flexible ureteroscopic aspects of caliceal calculi.**

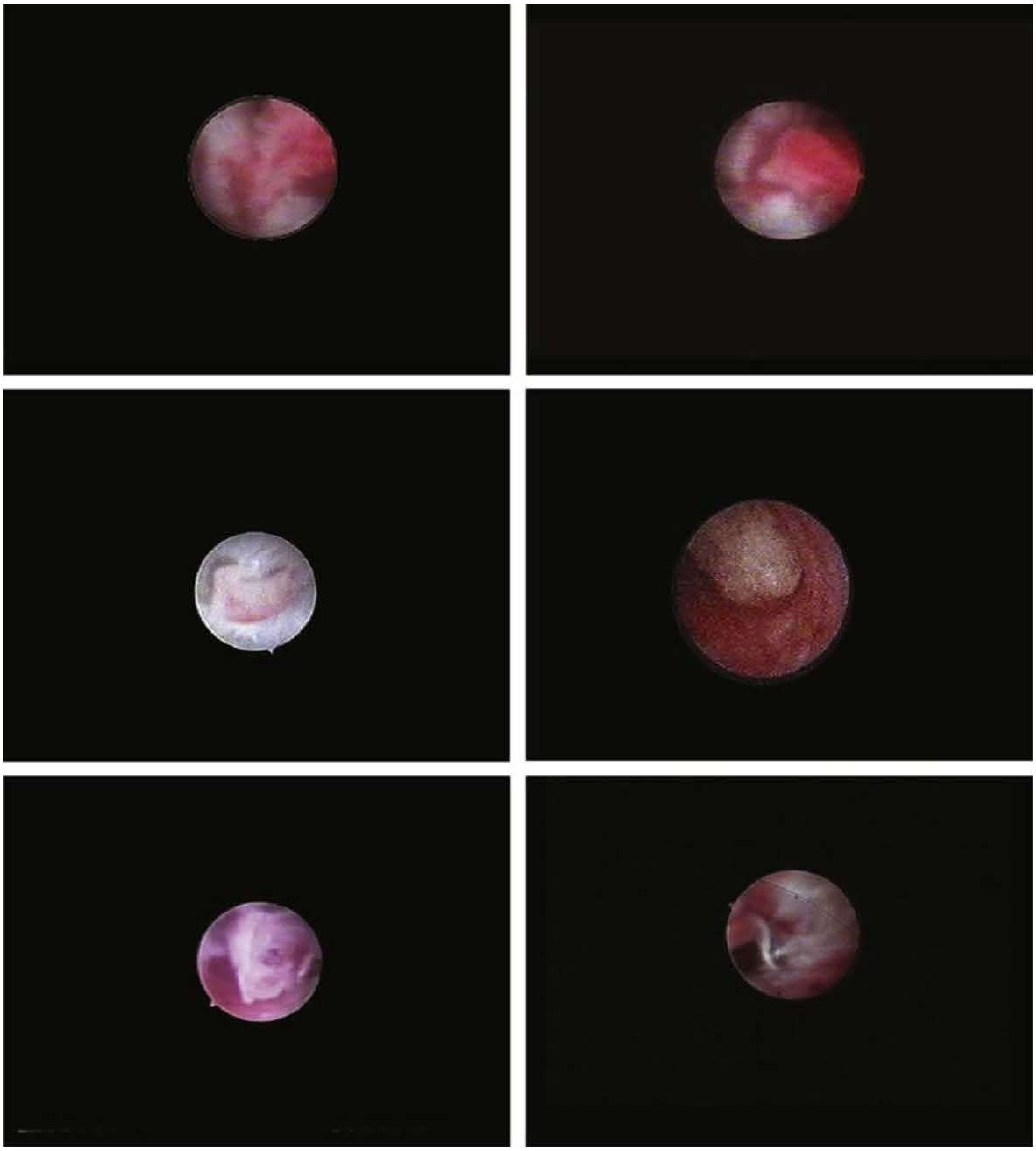


Figure 4.14 Flexible ureteroscopic aspects of pyelocaliceal urothelial tumors.

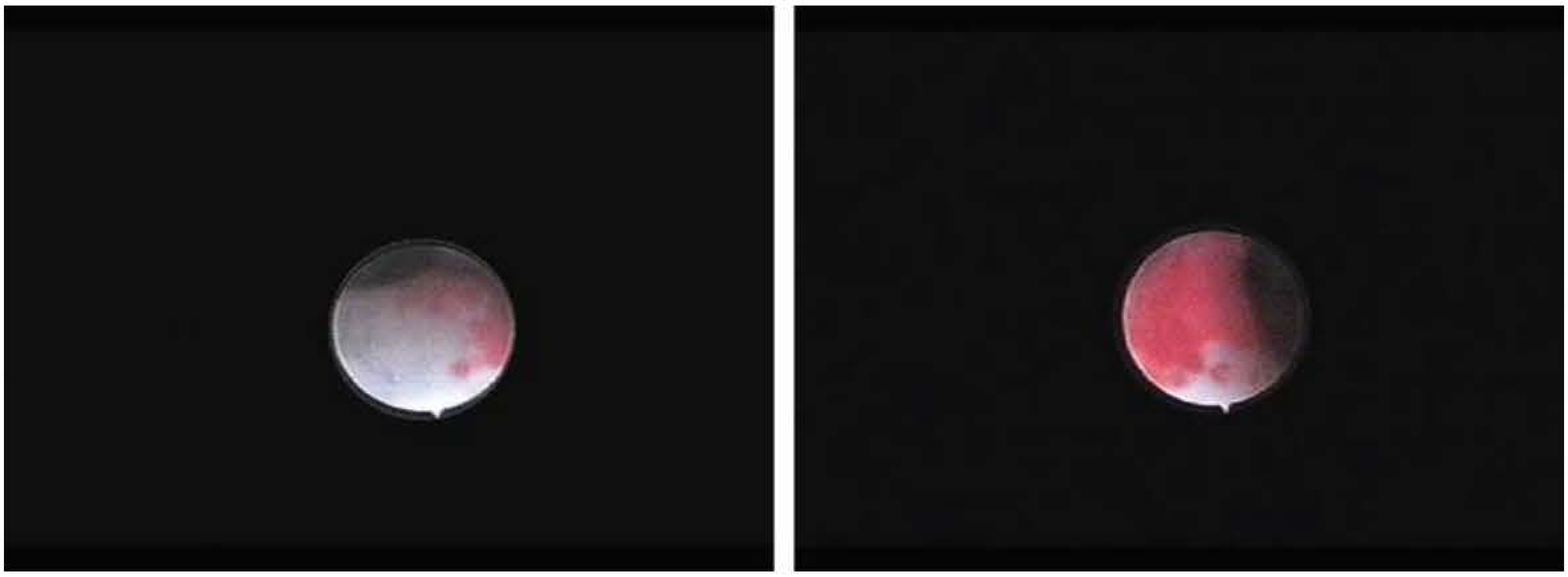
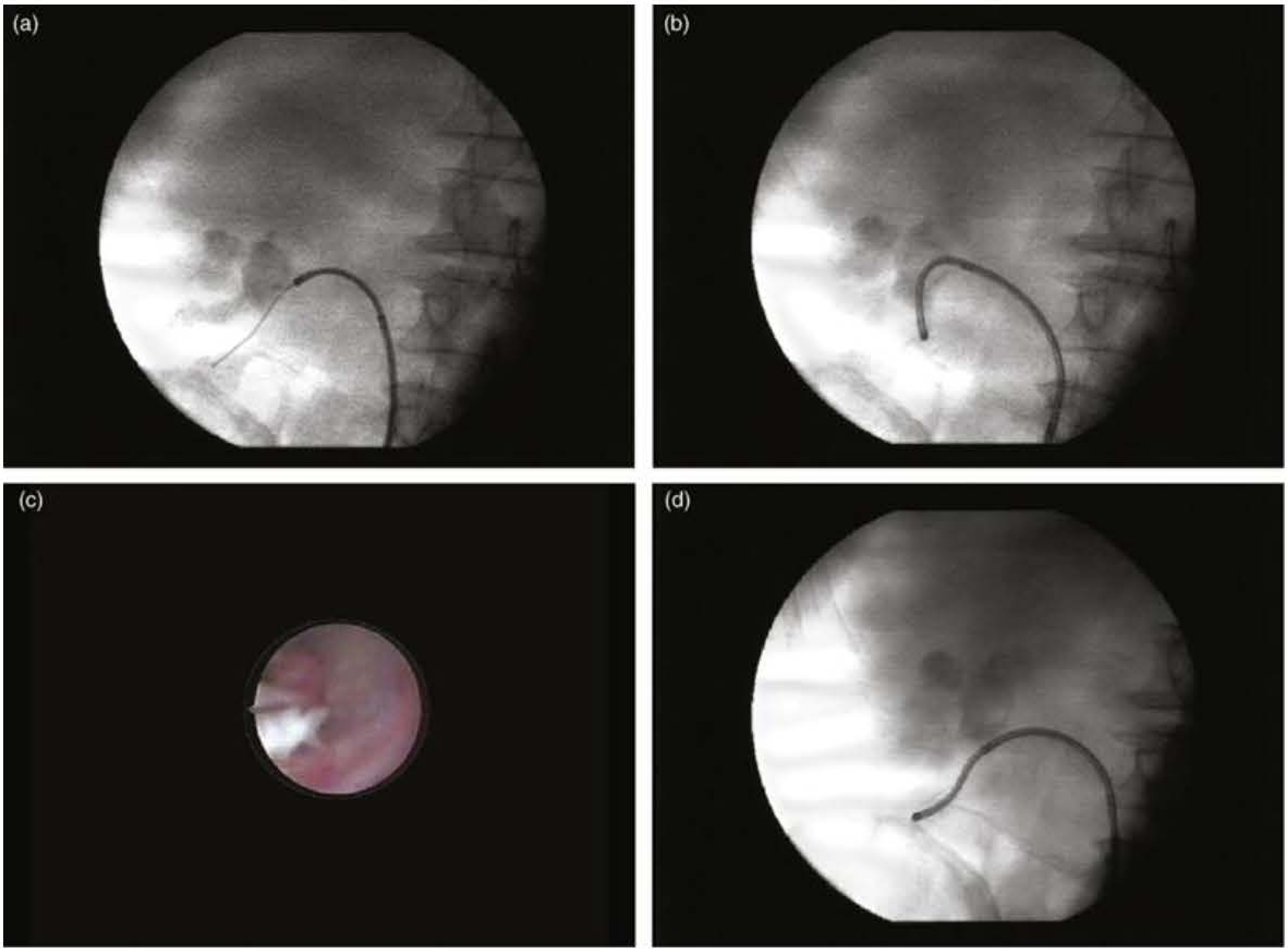


Figure 4.15 Carcinoma in situ lesions at the pyelocaliceal level.



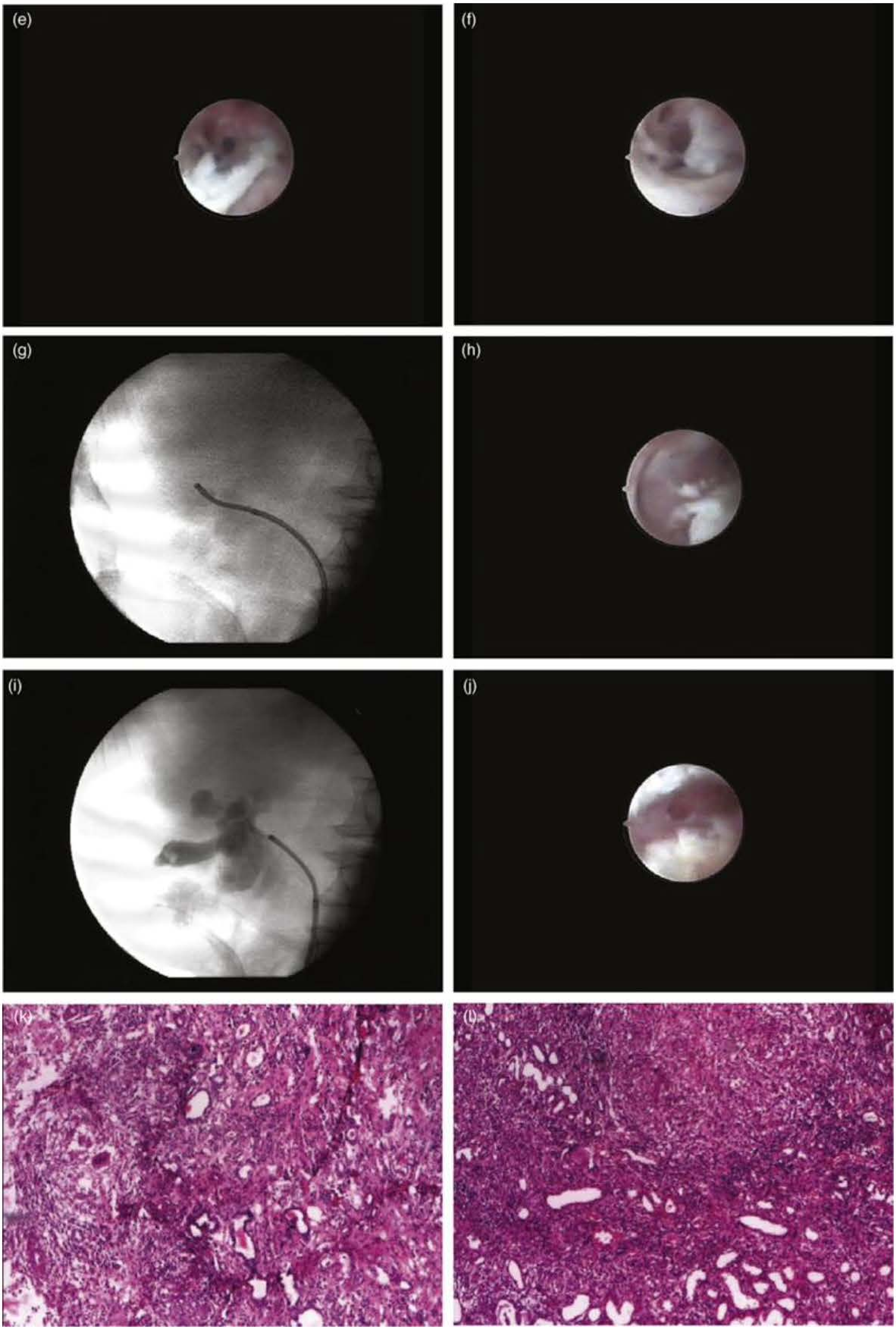


Figure 4.16 **Flexible ureteroscopy in a patient with total hematuria determined by renal tuberculosis opened into the urinary tract.**

Disorganized aspect of the pyelocaliceal system, with inhomogeneous opacification and lacunar images (intraoperatory fluoroscopy) (a), systematic exploration of all caliceal groups, with the detection of papilla ulcerations, white deposits and false exudate membranes (b–j), Koster follicle in the renal medulla (HE staining, 20×) (k, l).

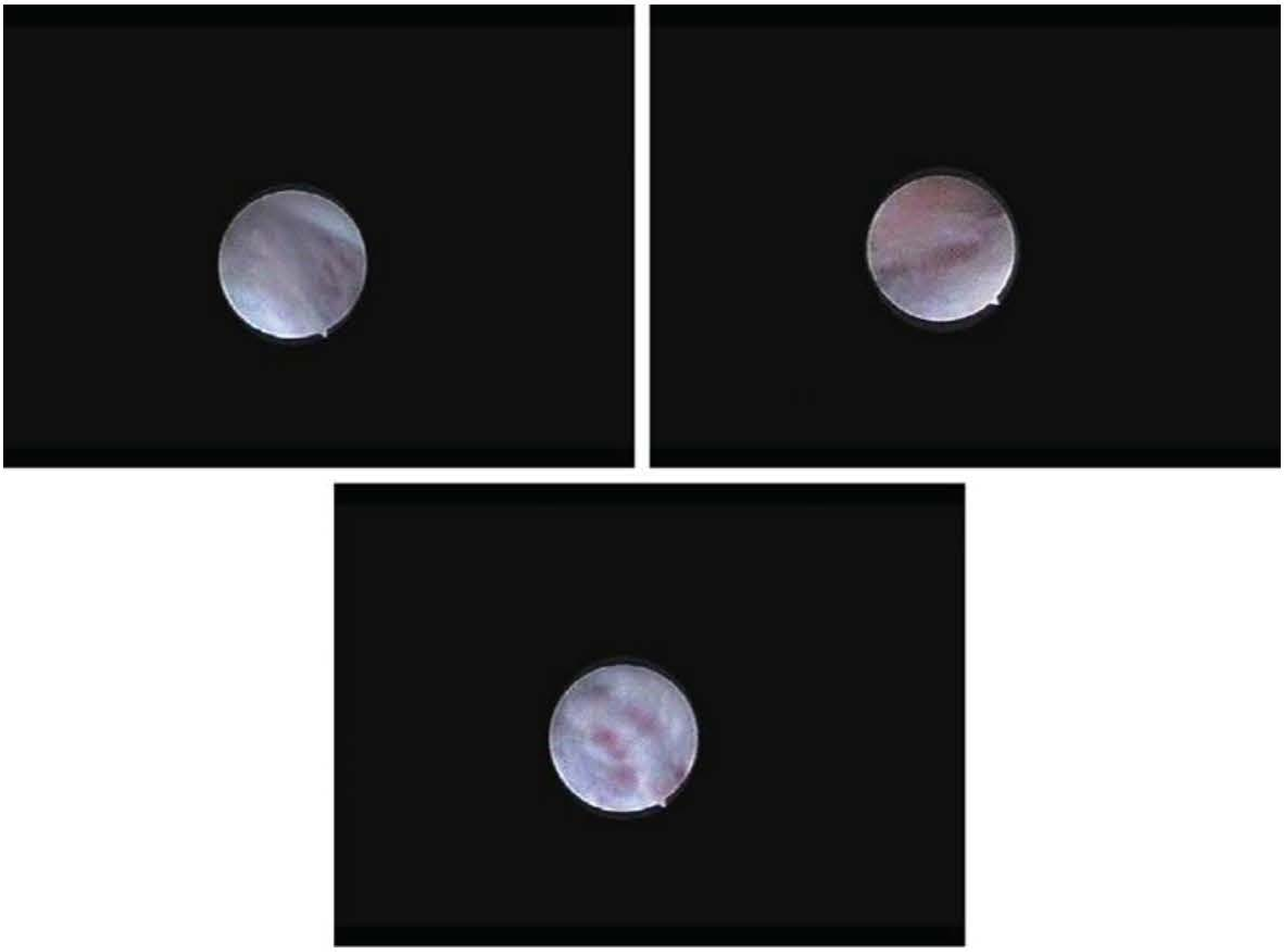


Figure 4.17 **Flexible ureteroscopic aspect suggestive of papillary necrosis.**

There are situations in which ureteroscopic exploration can only detect nonspecific lesions, such as congestion of the ureteral, caliceal or pelvic mucosa (Fig. 4.18), calcareous encrustations (Figs 4.19 and 4.20), etc., or even the absence of pathological modifications (Yazaki et al., 1999).

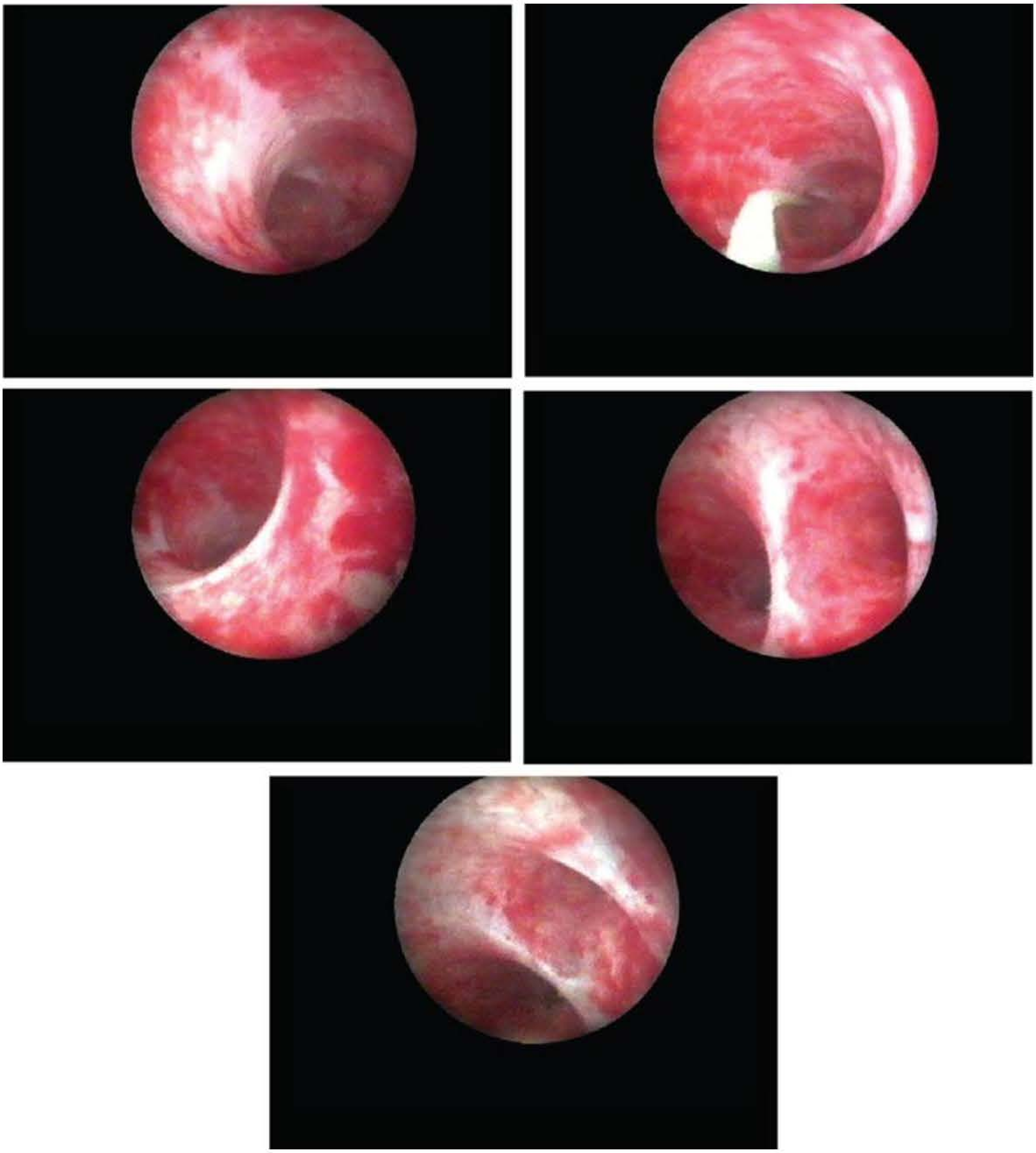


Figure 4.18 Intensely hyperemic pyelocaliceal mucosa in a patient with total hematuria.

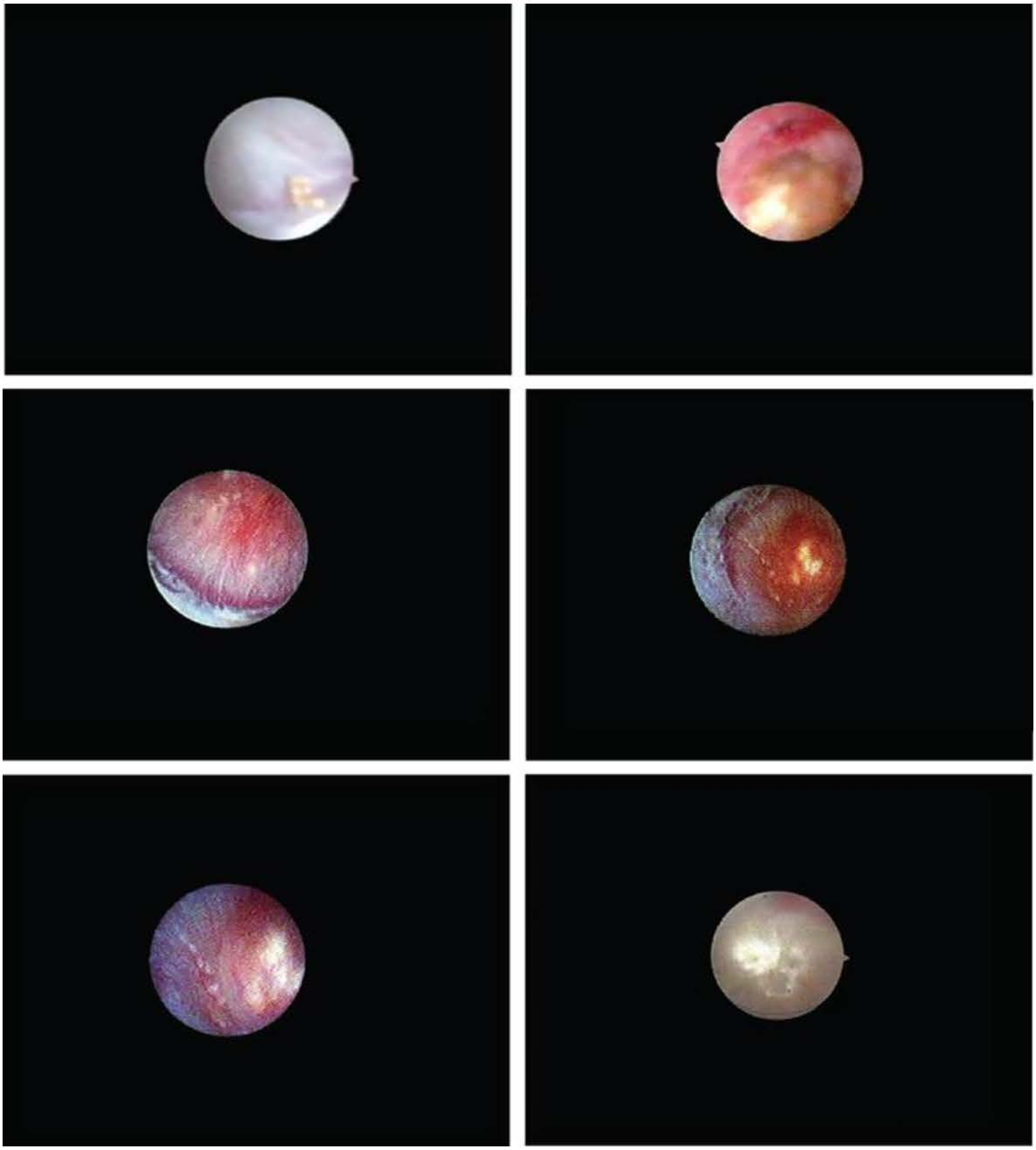


Figure 4.19 Papillary calcifications detected by flexible ureteroscopy in patients with unilateral total hematuria.

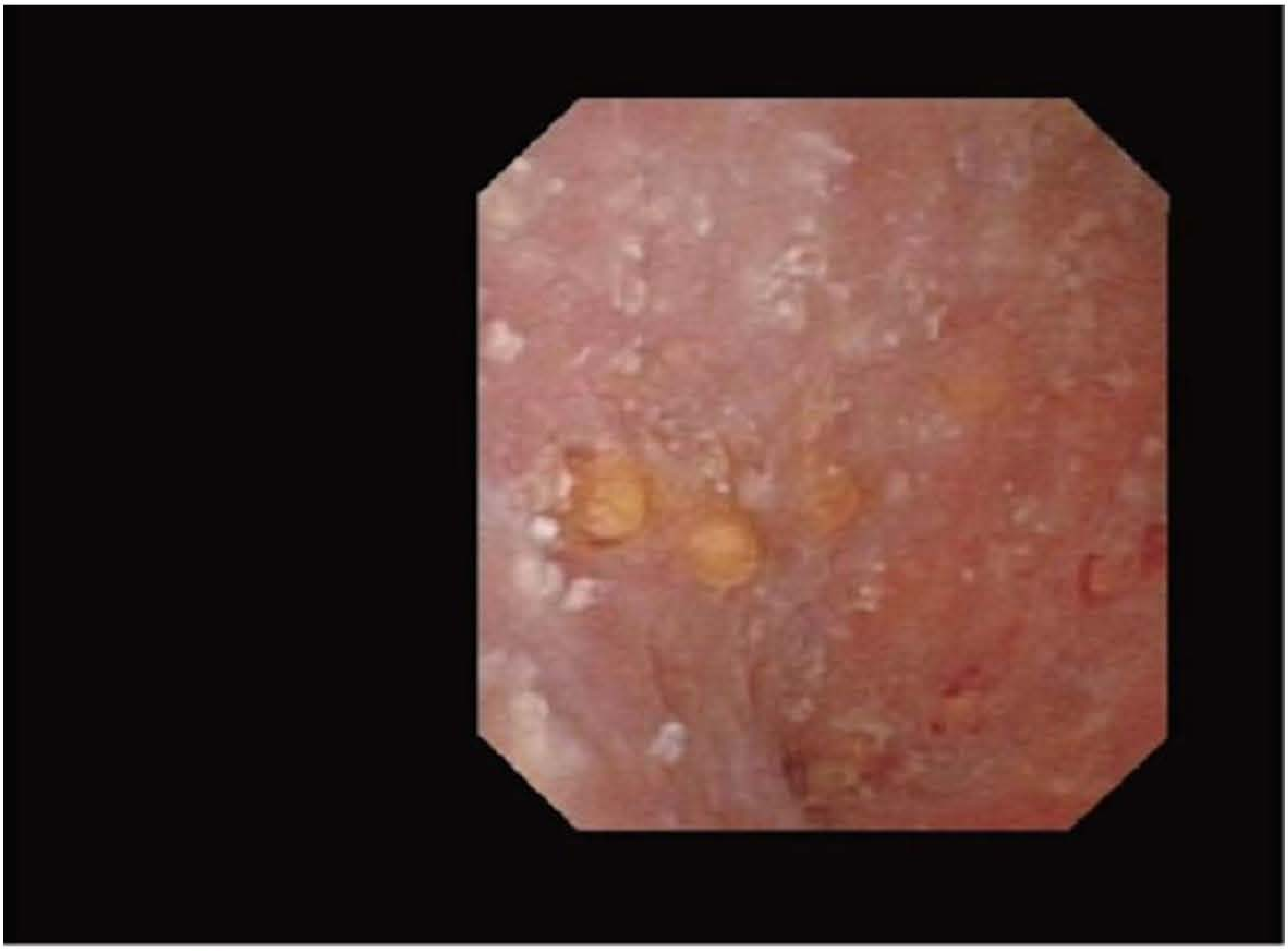


Figure 4.20 **Endoscopic aspect in a patient with nephrocalcinosis and hematuria.**

The use of flexible ureteroscopes, by thoroughly exploring areas of the upper urinary tract that used to be inaccessible to rigid and semirigid endoscopes, has reduced the number of cases diagnosed as "essential" hematuria (Bagley and Allen, 1990; Liatsikos et al., 2001).

When determining the malignant or benign nature of lesions is difficult under white light, the NBI mode available in the case of the Olympus URF-Vo ureteroscope may provide additional visual information in order to decide on the course of action (biopsy or not) (Figs 4.21–4.24). This mode also allows for a better surface characterization of tumors when conservative treatment is chosen.

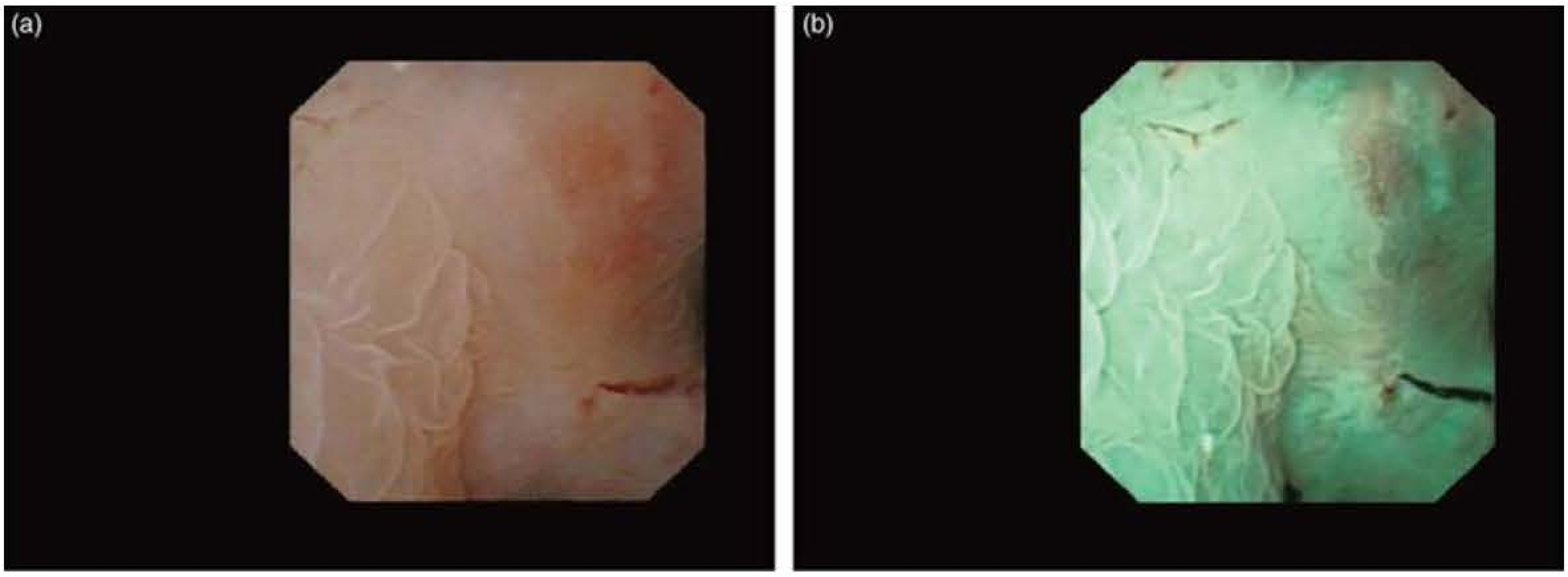


Figure 4.21 **Edema of the pyelocaliceal system (a), without tumoral characteristics in NBI (b).**

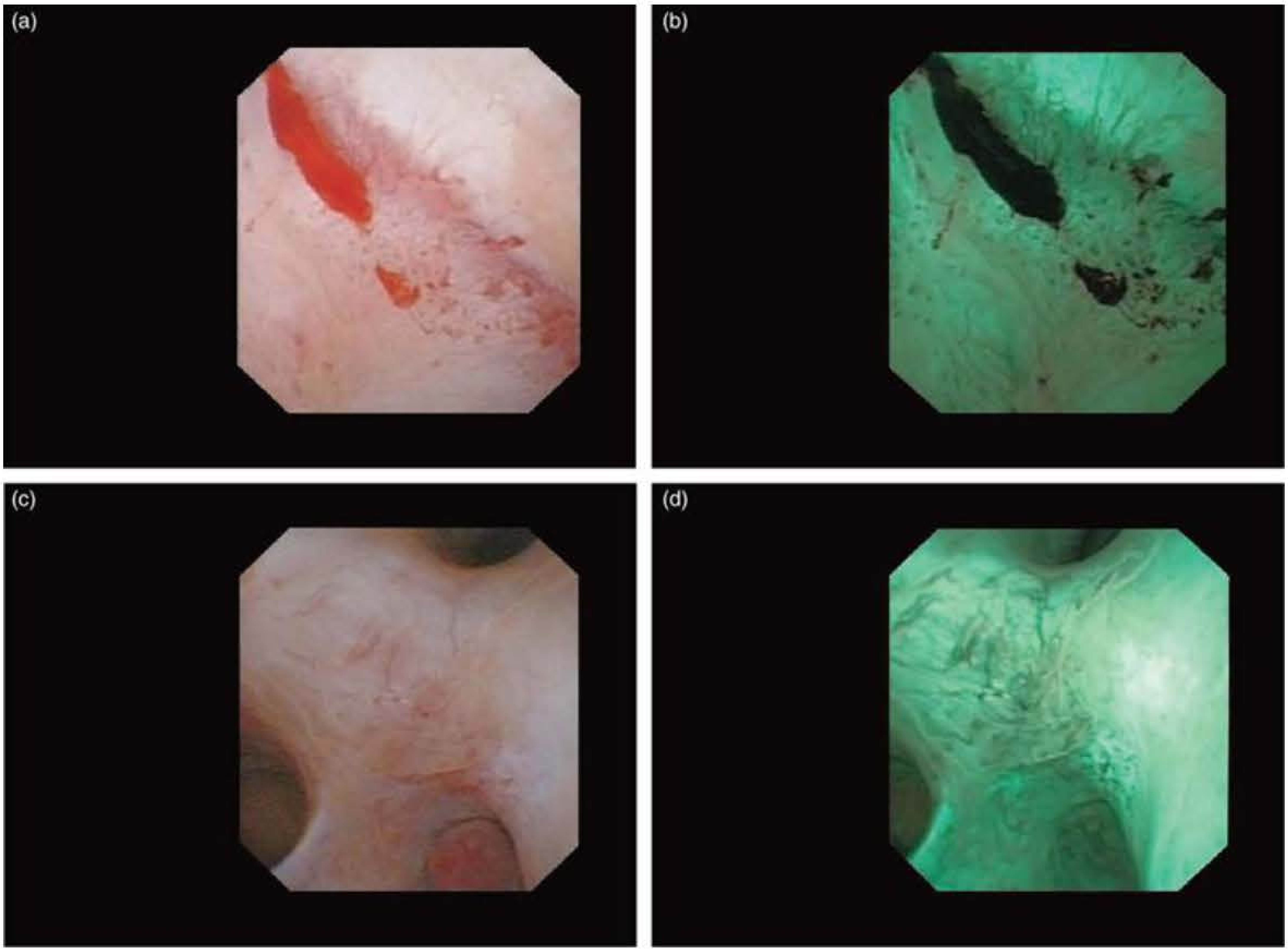


Figure 4.22 Superficial lesions (a, c), having tumoral characteristics in NBI (b, d).

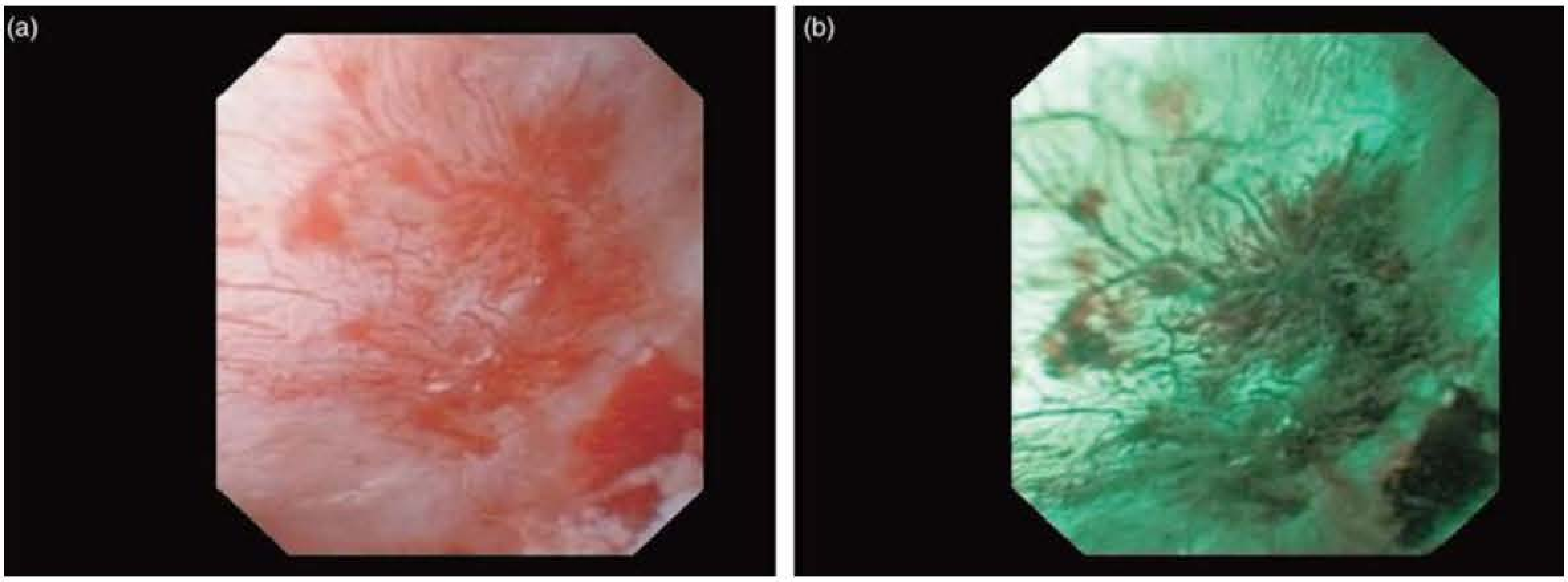


Figure 4.23 Flat lesion, suspected for CIS (a), without tumoral aspect in NBI (b).

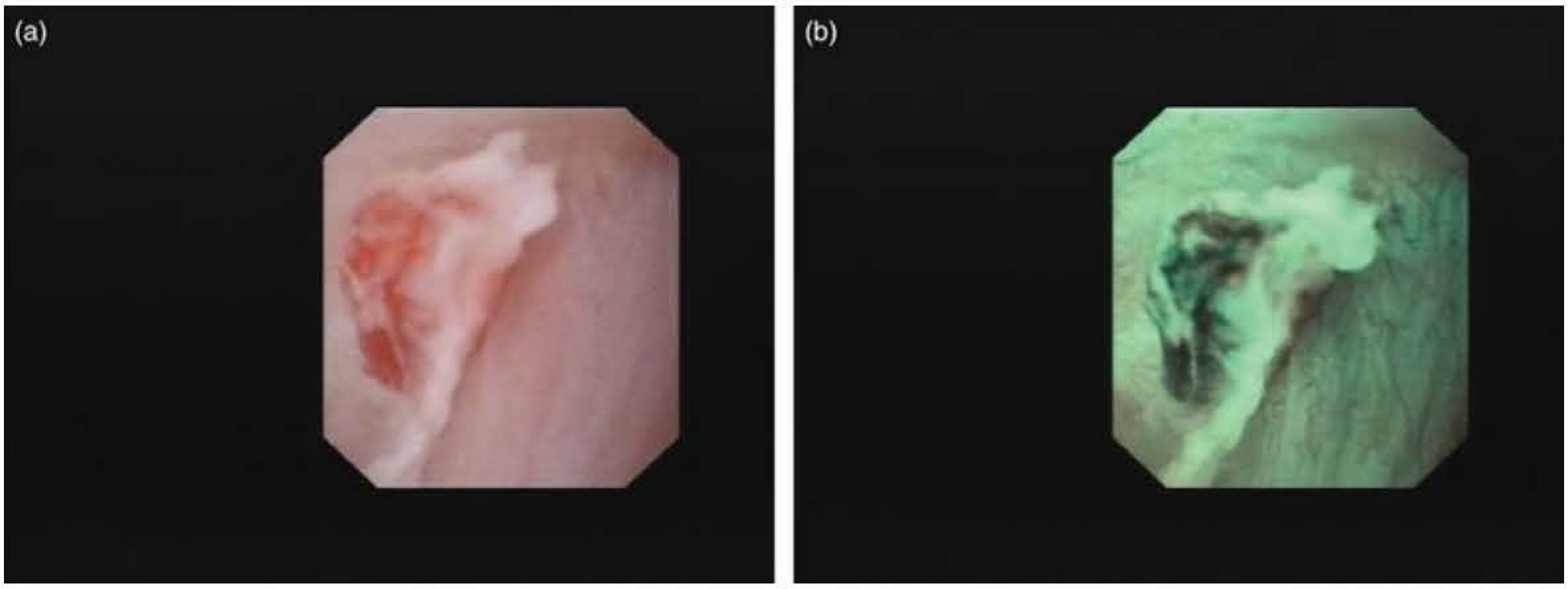


Figure 4.24 **Caliceal mucosal lesions (a), without NBI tumor characteristics (b).**

4.2.3. Abnormal Results of Cytological Tests

Another indication for ureteroscopic evaluation is represented by patients with abnormal urinary cytology (Kurimura et al., 2007), with normal urethrocystoscopy and, eventually, with negative bladder and prostatic urethra biopsies.

Due to the theoretical possibility of visualizing the entire upper urinary tract, eventually with sampling of bioptic material, ureteroscopy has a 93% sensitivity, compared to only 72% for imaging methods (Davenport and Keeley, 2007).

4.2.4. Follow-Up of Conservatively Treated Upper Urinary Tract Urothelial Tumors

In selected cases, patients with upper urinary tract urothelial tumors have an indication for conservative endourological treatment: tumor on the solitary kidney, patients with kidney failure, bilateral synchronous tumors, and important surgical risk.

Due to the high risk of tumor recurrence, the follow-up protocol for these patients must be very strict, the periodic endoscopic exploration of the entire upper urinary tract also being necessary (Fig. 4.25).

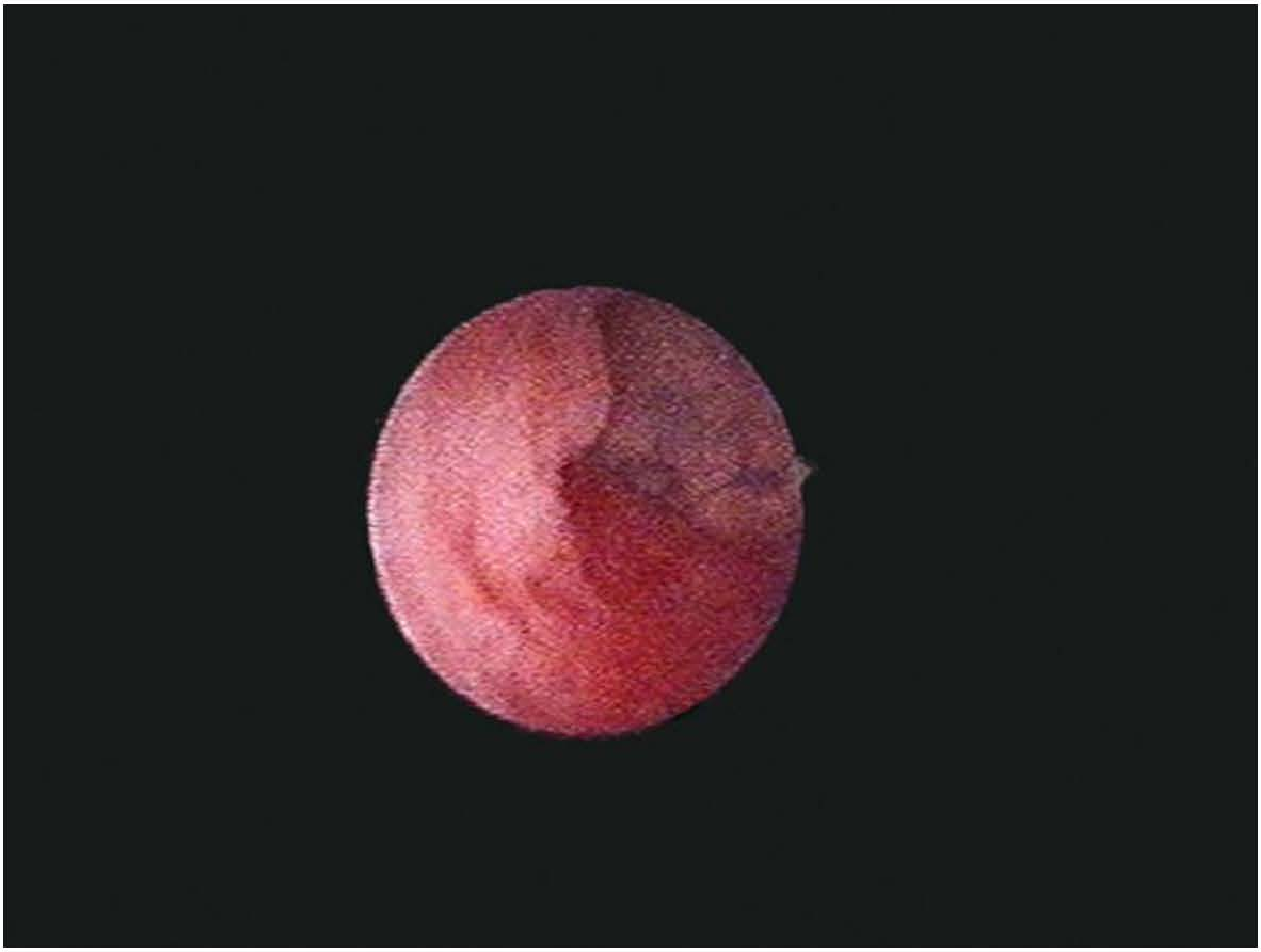


Figure 4.25 **Recurrent urothelial tumor after conservative treatment.**

In a study performed on a group of 10 patients (12 renal units) with conservatively treated upper urinary tract urothelial tumors, Amon Sesmero and Estebanez Zarranz performed 42 ureteroscopies (31 with flexible instruments and 11 with rigid endoscopes) in a mean follow-up period of 31.9 months. Two patients presented ureteroscopically identified tumor recurrences and two patients died, one from distant progression and the other due to a metachronous bladder tumor, chronologically previous to the ureteral one (Amon Sesmero et al., 2004). In the opinion of the authors, flexible ureteroscopy is the most efficient follow-up method for these patients.

4.2.5. Other Indications for Diagnostic Ureteroscopy

Ureteroscopy may also contribute to the etiological diagnosis of obstructions at the ureteral or uretero-pelvic junction level. As in the case of the diagnosis of filling defects, ureteroscopic approach allows for direct visualization of lesions (calculus, tumor, ureteral, or uretero-pelvic junction stenosis), eventually with sampling of bioptic material and, very frequently, with their conservative treatment.

In selected cases, with certain anatomical particularities (such as important ureteral curves, urinary derivations, and malformations of the urinary tract), the use of flexible ureteroscopes may be absolutely necessary for the diagnosis of the upper urinary tract obstruction's etiology.

Incomplete pathological pyeloureteral duplicity represents an entity that benefits, in selected cases, from ureteroscopic evaluation and treatment (Geavlete et al., 2001).

The use of flexible ureteroscopes allows for the visualization, in good conditions, of the bifurcation areas and for the direct exploration of all pelvises, in order to determine the type of obstruction and any associated conditions.

The effects of lesions located outside the urinary tract (retroperitoneal diseases, digestive, or gynecological cancers, kidney cysts, Grawitz tumors, etc.) on the urinary tract can be evaluated or confirmed by retrograde ureteroscopic approach (Fig. 4.26).

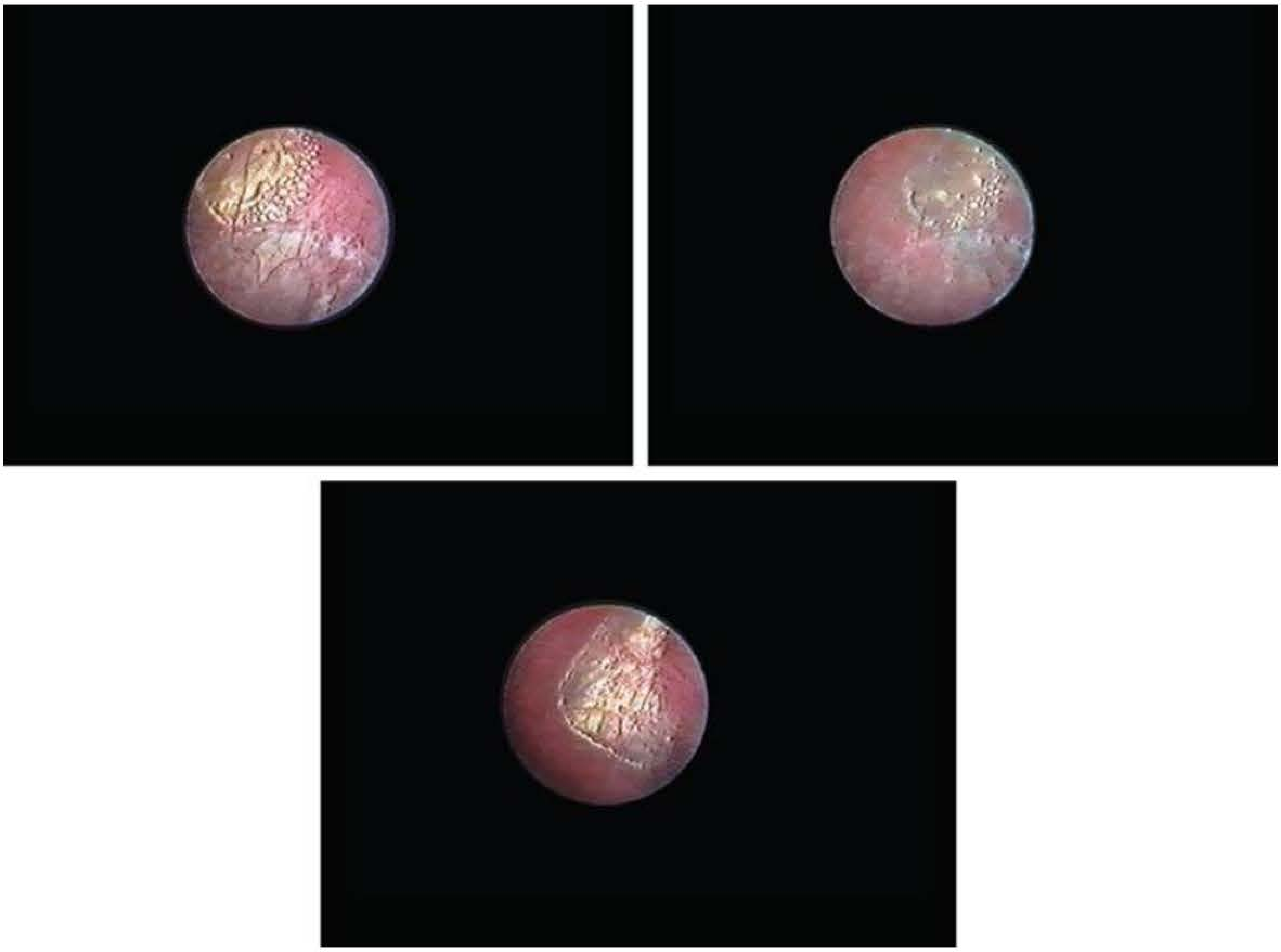


Figure 4.26 **Kidney cyst visualized through the transparency of the caliceal wall.**

4.2.6. Contraindications

The contraindications of diagnostic ureteroscopy are few, all of them being considered as relative:

- hemorrhagic disorders
- neglected urinary tract infections
- lack of appropriate antibiotic prophylaxis

Adequate preoperatory preparation (correction of coagulation, antibiotic treatment, or prophylaxis, etc.) may allow for performing the ureteroscopic exploration in good conditions in these cases as well.

The introduction of flexible ureteroscopes into current urological practice allows one to perform this investigation also in patients in whom semirigid ureteroscopic approach used to be difficult or even impossible (skeletal deformities, voluminous prostate adenomas, etc.)

4.3. Diagnostic ureteroscopy technique

4.3.1. Preliminary Measures

Retrograde ureteropyeloscopic exploration for diagnostic purposes is performed with the patient in the classic lithotomy position.

In contrast to rigid ureteroscopy, which requires spinal or epidural anesthesia in most cases, analgosedation can be sufficient for ureteroscopic exploration using flexible instruments (Cybulski et al., 2004).

In selected cases, spinal, epidural, or even general anesthesia may be required for performing this procedure.

4.3.2. Cystoscopy

As is the case for any endoscopic intervention on the upper urinary tract, the first step is represented by flexible or rigid cystoscopy in order to determine the morphology and size of the ureteral orifice and any associated bladder conditions.

4.3.3. Inspection of the Ureter

The instrumentation of the upper urinary tract before visualizing the areas of interest must be minimal because the potential iatrogenically induced lesions may hinder the establishment of a correct diagnosis.

A small caliber semirigid ureteroscope (of 7–8 F) may be used for ureteral exploration.

If the ureteroscope's insertion requires the presence of a guidewire, this will only be introduced a few centimeters, just enough to pass the ureteral orifice with the endoscope.

The semirigid ureteroscope will be slowly ascended, evaluating the entire circumference of the ureteral wall to identify any pathological modifications at this level (Fig. 4.27). After reaching the proximity of the junction and after inspecting this segment (Fig. 4.28), a guidewire will be inserted through the ureteroscope, the tip of which must remain in the visual field and must not pass the uretero-pelvic junction.

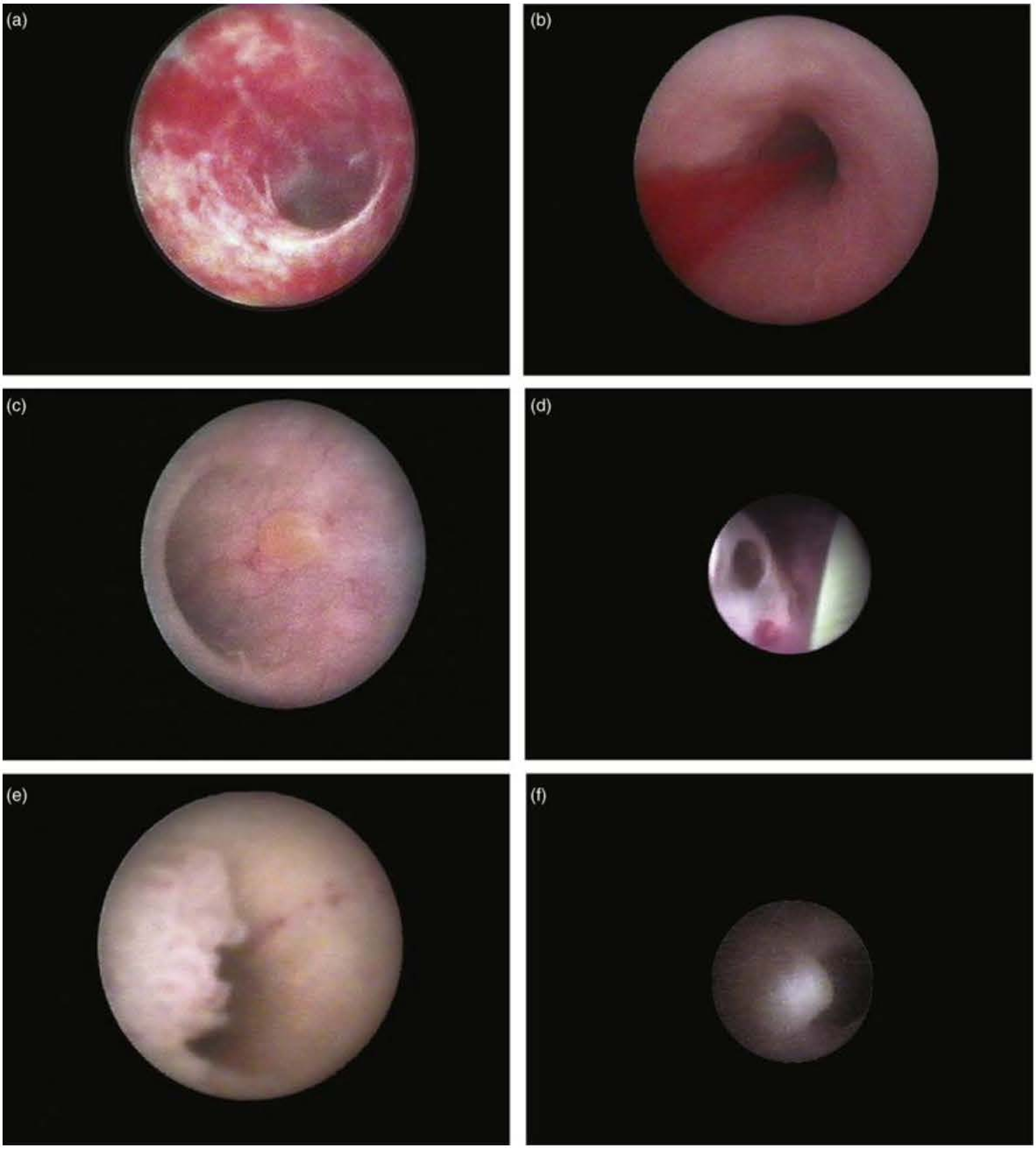


Figure 4.27 Ureteral lesions detected by semirigid ureteroscopy.
Hyperemic ureteral mucosa (a), blood clot on the ureter (b), pseudotumoral ureteral mass (c), necrosis of the ureteral wall (d), fibroepithelial ureteral polyp (e), ureteral tumor (f).

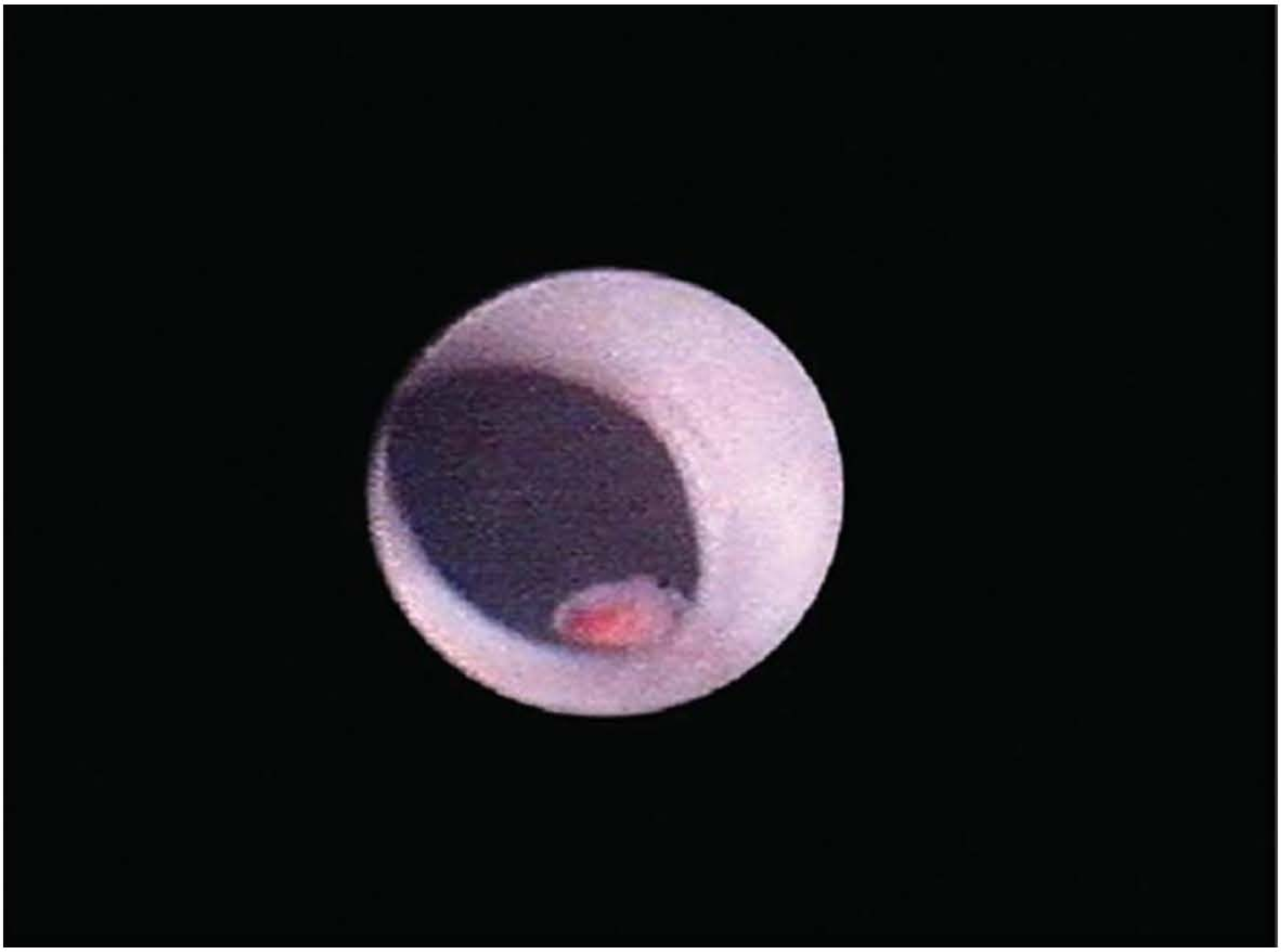


Figure 4.28 **Tumoral mass of the uretero-pelvic junction.**

In this stage, the semirigid ureteroscope is extracted, while the correct position of the guidewire is checked fluoroscopically. The flexible ureteroscope will be inserted by sliding it to the uretero-pelvic junction level (Fig. 4.29), the guidewire being extracted immediately afterward.

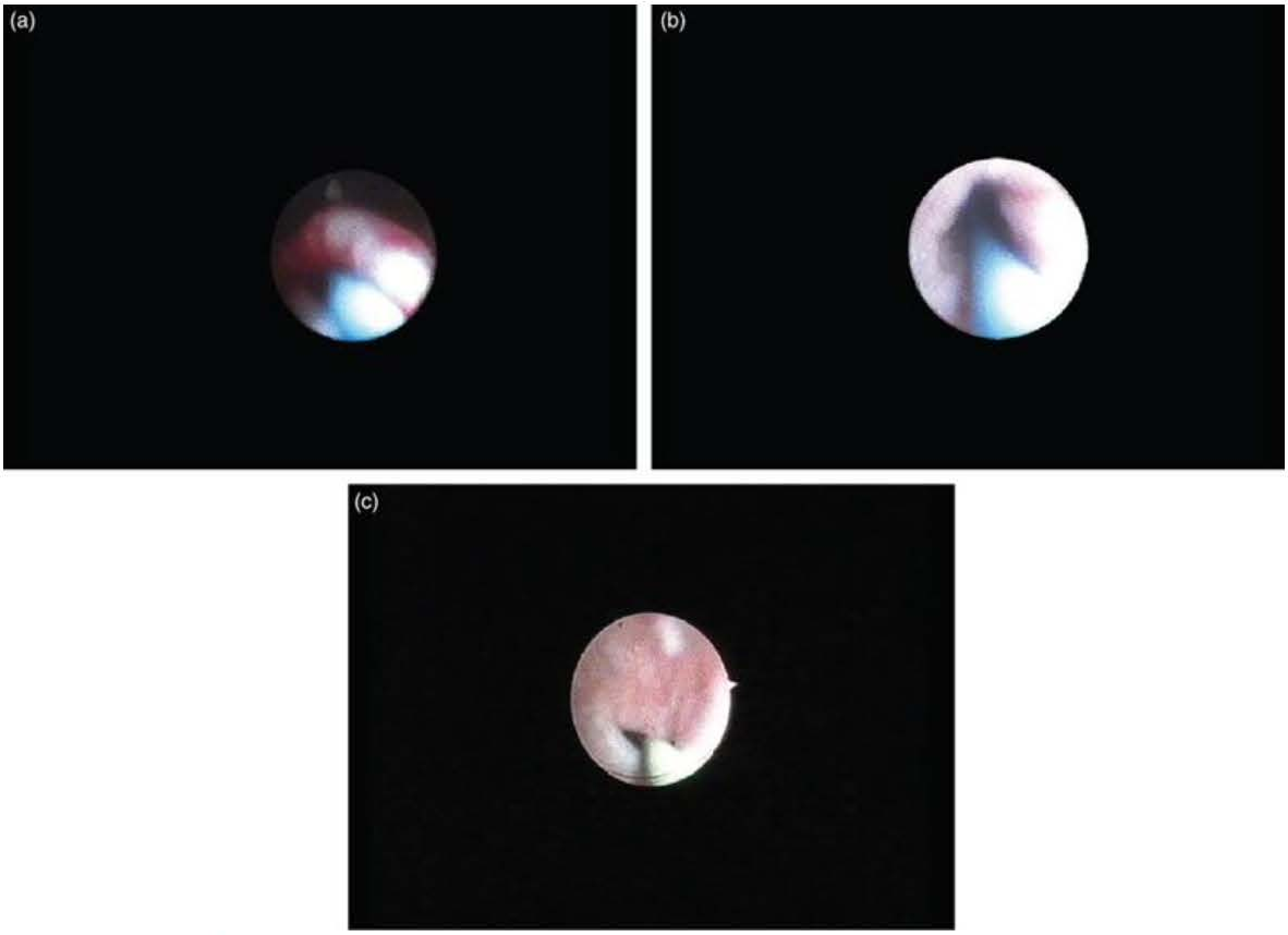
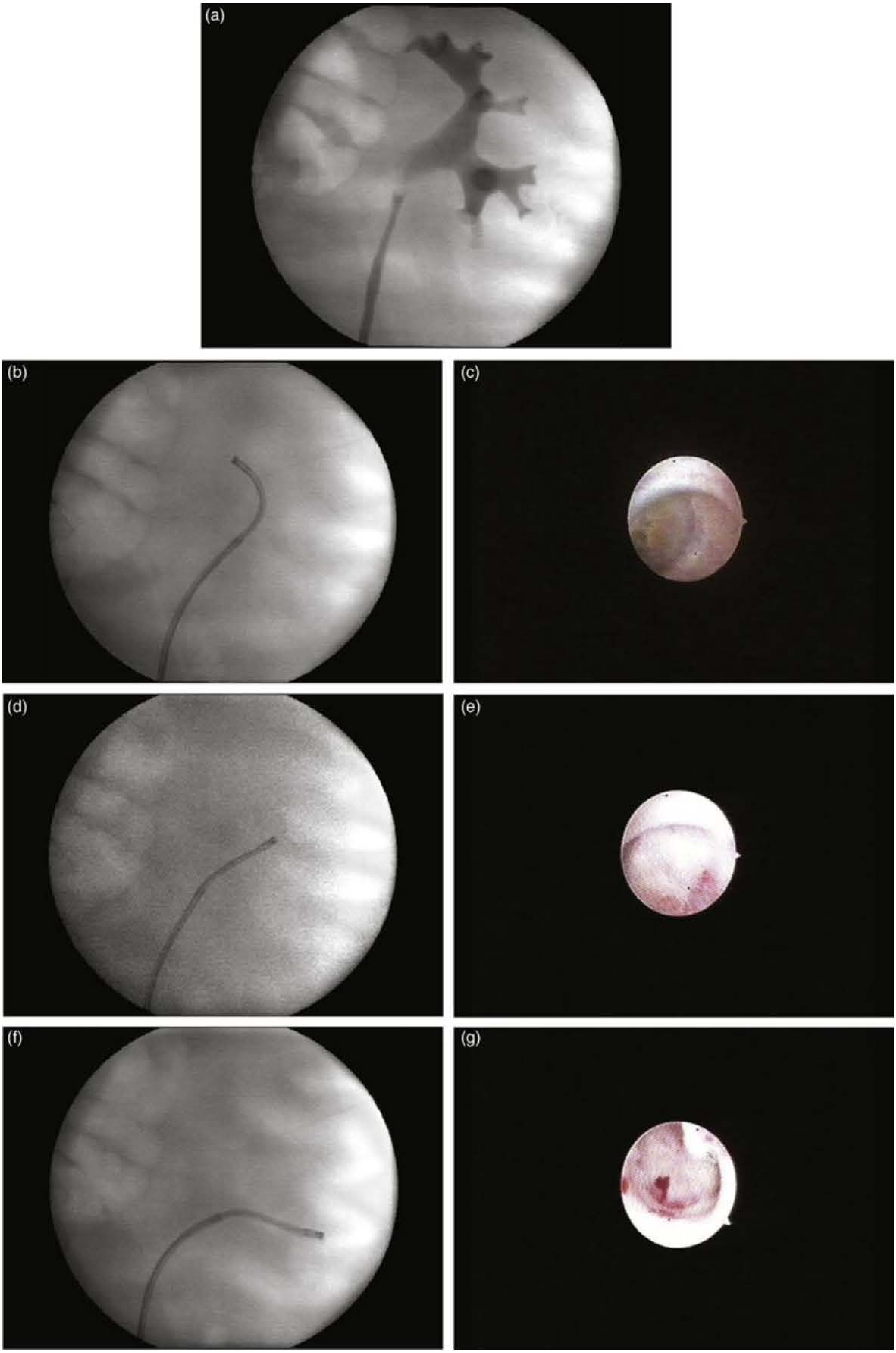


Figure 4.29 **Insertion of the flexible ureteroscope into the upper urinary tract.**
Passing the ureteral orifice (a), ascending up to the ureteral level (b), visualizing the uretero-pelvic junction (c).

Some authors also recommend inspecting the junction and the renal pelvis, using the semirigid ureteroscope.

4.3.4. Inspection of the Pyelocaliceal System

Examination will be performed systematically: first, the uretero-pelvic junction and the renal pelvis, followed by the upper, middle, and lower calyces. The position of the ureteroscope will be confirmed periodically, by fluoroscopic control, by injecting a 30–50% concentration contrast agent through the working channel (Fig. 4.30). In general, the radiological localization and guiding of the ureteroscope's distal end is easier than the visual, endoscopic one. Some authors recommend numbering each calyx during the pyelography (perhaps with a temporary marker directly on the fluoroscope's screen), in order to subsequently ensure their methodical endoscopic inspection (Monga and Beeman, 2004).


(a)
(b)
(c)
(d)
(e)
(f)
(g)

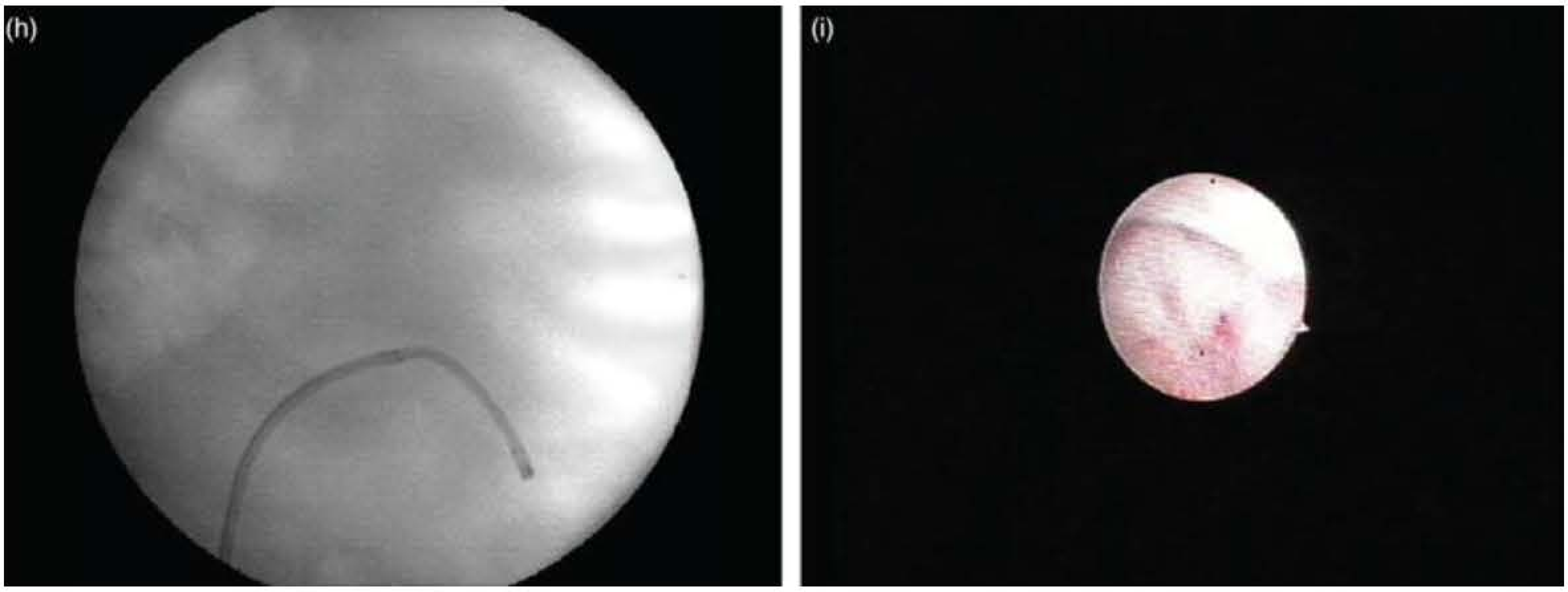


Figure 4.30 **Inspection of the pyelocaliceal system.**
Evaluation of anatomy through retrograde pyelography (a), inspection of the upper secondary calyces (b–e), of the middle calyx (f, g), and of the lower calyx (h, i).

The approach of the lower calyx may require, especially in case of flexible endoscopes with a passive deflection, leaning the distal part of the ureteroscope on the renal pelvic wall or on the insertion area of the upper calyx infundibulum at this level (Fig. 4.31), due to the possibility of producing lesions that could hinder diagnosis (Fig. 4.32). This is the reason for the recommendation to begin the exploration from the upper calyces toward the lower ones.

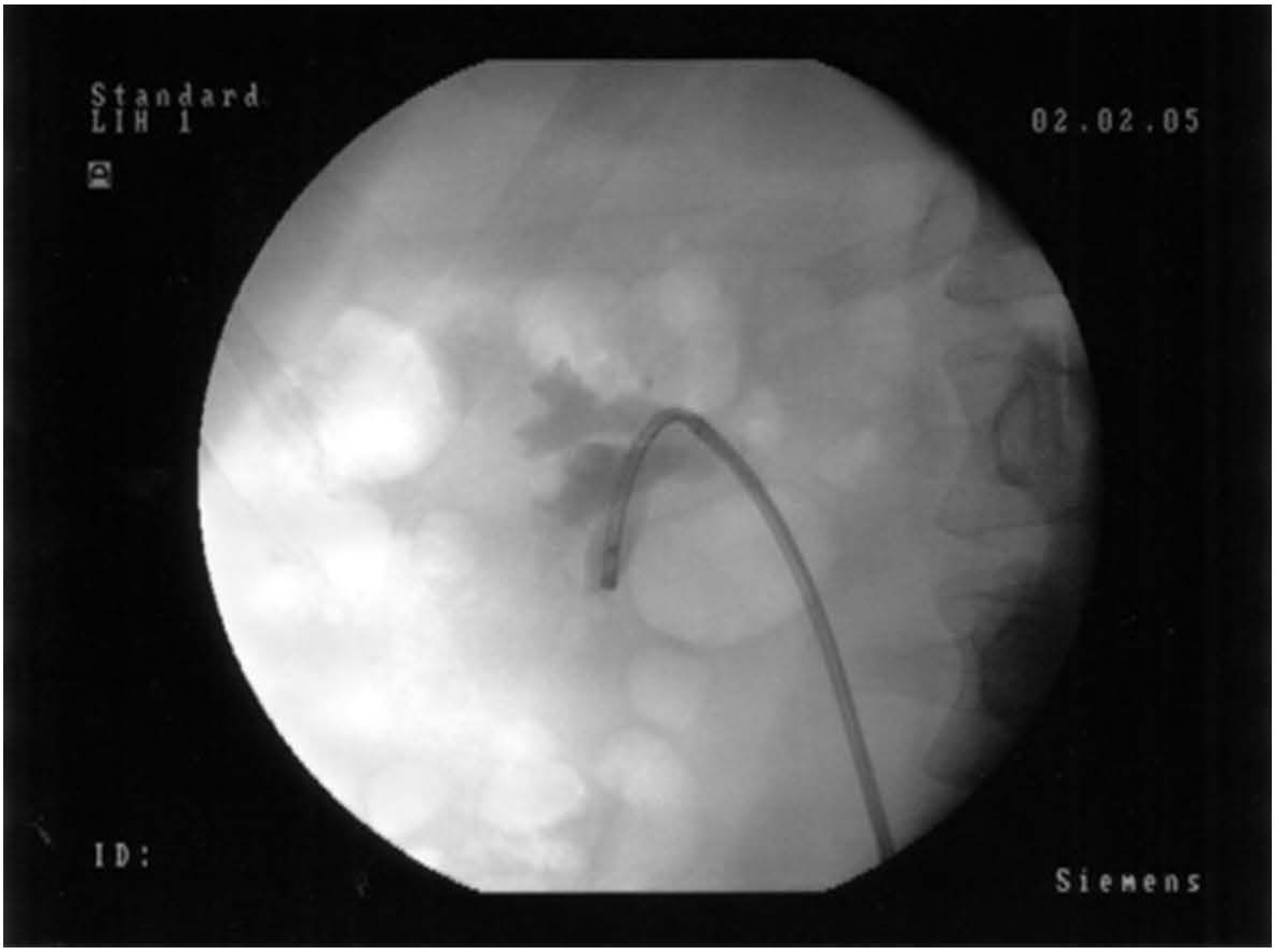


Figure 4.31 **The way of obtaining passive deflection, by leaning the ureteroscope on the cranial part of the renal pelvis (intraoperatory fluoroscopy).**

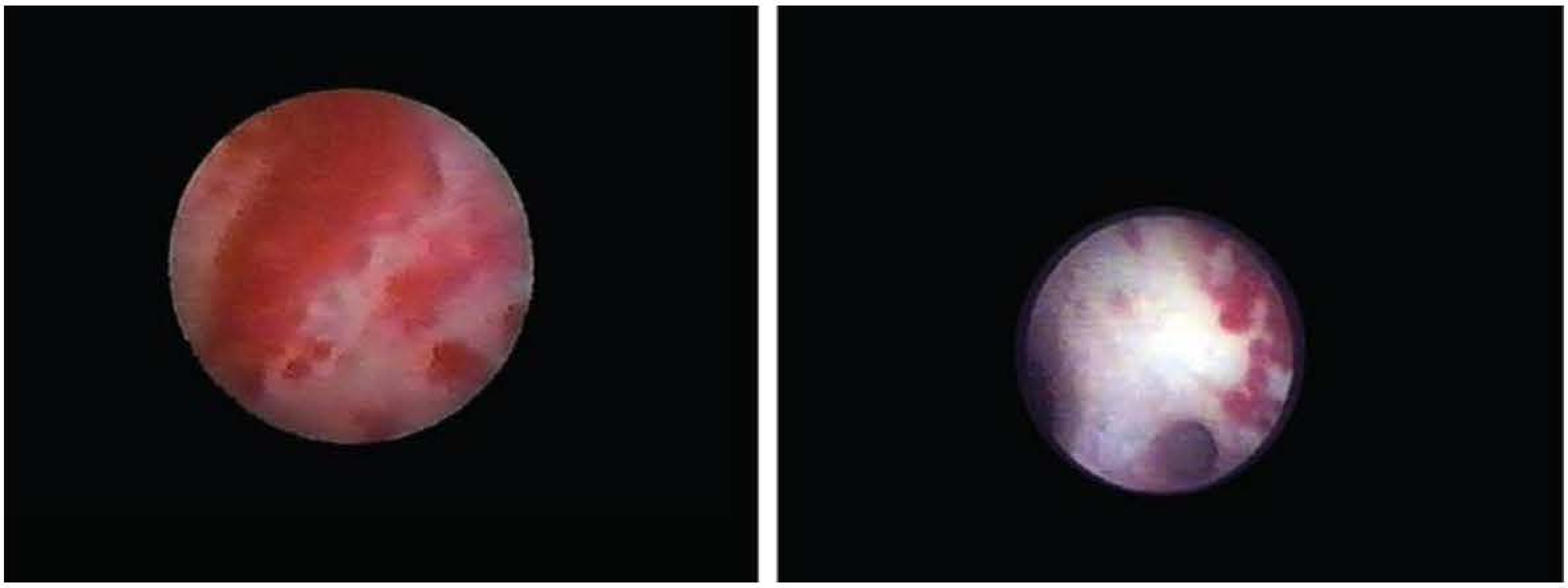


Figure 4.32 Iatrogenic petechial lesions produced while obtaining passive deflection.

4.3.5. Identifying Upper Urinary Tract Lesions

Irrigation under increased pressure can mask a series of lesions (such as bleeding due to rupture of venous ectasias) due to their simple collapse (Dooley and Pietrow, 2004). During diagnostic flexible ureteroscopy, the use of a reduced irrigation flow is recommended (with a pressure lower than 40 cm H_2O) and even its periodic interruption, with the monitoring of potential bleeding sources (Fig. 4.33).

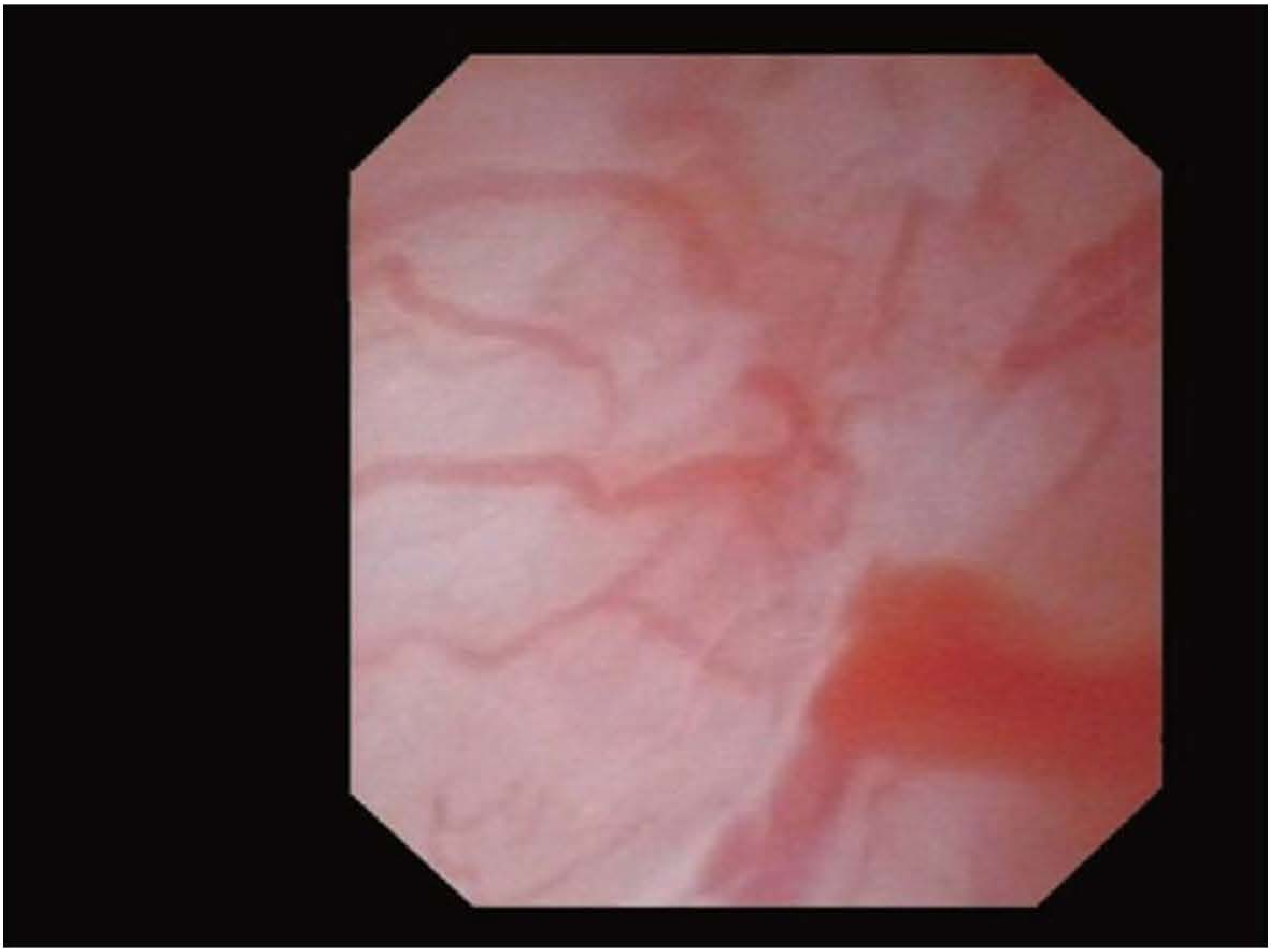


Figure 4.33 Active bleeding source, visible once the irrigation flow has been reduced.

4.3.6. Taking Biopsy Samples

The identification of potentially malignant lesions must be followed by the sampling of cells or tissues for anatomopathological exam. Also, if inflammatory type lesions are detected, the sampling of material for bacteriological exam may be necessary.

Several methods of sampling have been described:

4.3.6.1. Simple Aspiration

By simply adapting a syringe to the working channel, the liquid from the lesion's vicinity can be suctioned in order to be sent for cytological or microbiological exam.

4.3.6.2. Brush Biopsy

This method ensures the sampling of cellular material resulting from exfoliation. A biopsy brush is ascended through the ureteroscope and applied on the lesion. After several passes over its surface, the brush is withdrawn and the cellular material on it will be used to perform the cytological exam. The ureteroscope is again ascended to the level of the lesion and the area is irrigated with saline. This liquid will be suctioned with the help of a syringe adapted to the ureteroscope's irrigation channel and will also be subjected to cytological exam (Su and Sosa, 2002).

4.3.6.3. "Cold-Cup" Biopsy

This method implies the use of a 3 F diameter biopsy forceps. Once the lesion is visualized, the biopsy forceps is inserted into the ureteroscope's working channel until it becomes visible at the level of the distal end. With the two arms completely open, the forceps is advanced to the level of the lesion, after which it will be closed, catching an amount of tissue (Figs 4.34–4.36). The forceps can be withdrawn through the ureteroscope's working channel or together with the endoscope (in the latter variant, the use of a ureteral access sheath may be useful). It is recommended to perform multiple biopsies, inclusively from the base of the mass, in order to obtain more accurate results (Su and Sosa, 2002).

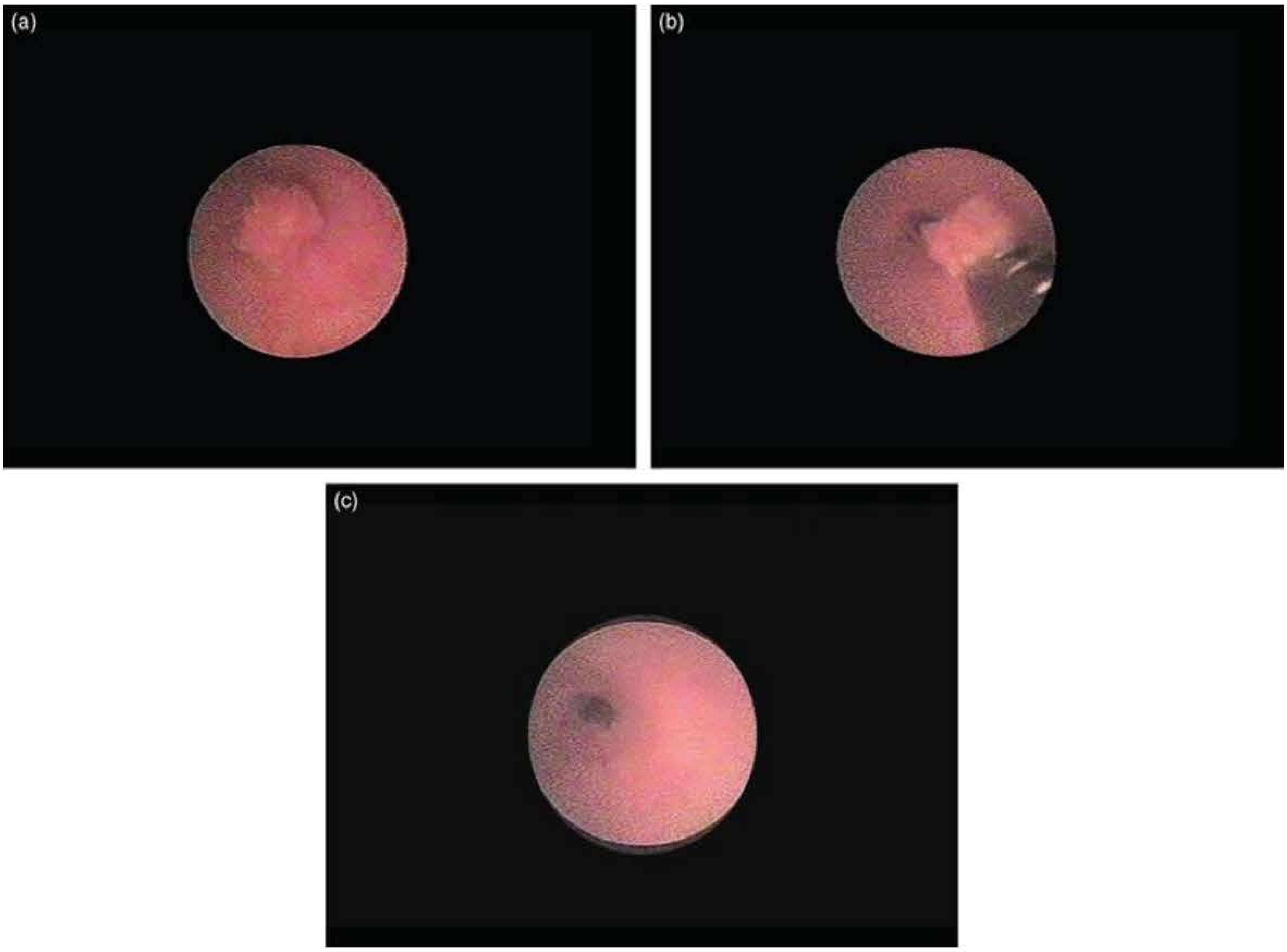


Figure 4.34 **"Cold-cup" biopsy of a ureteral lesion.**
Ureteral tumoral mass (a), forceps biopsy (b), ureter's aspect at the end of the intervention (c).

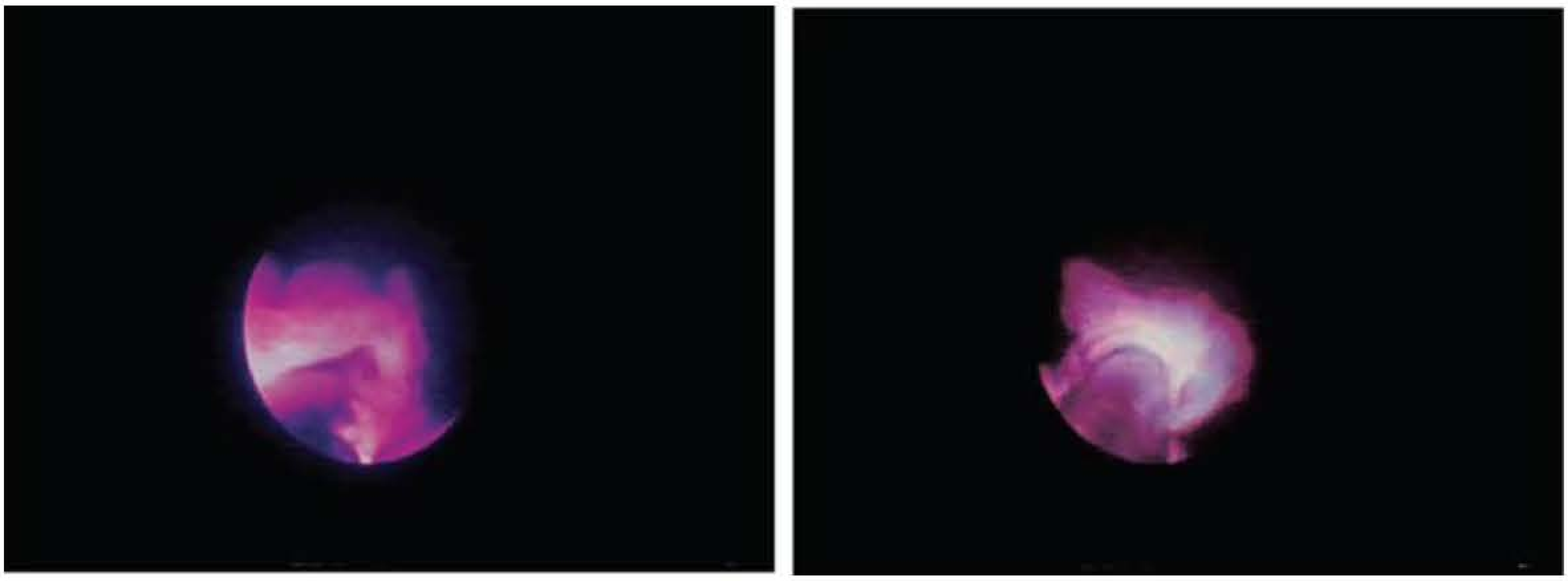


Figure 4.35 Forceps biopsy of a caliceal pseudotumoral mass.

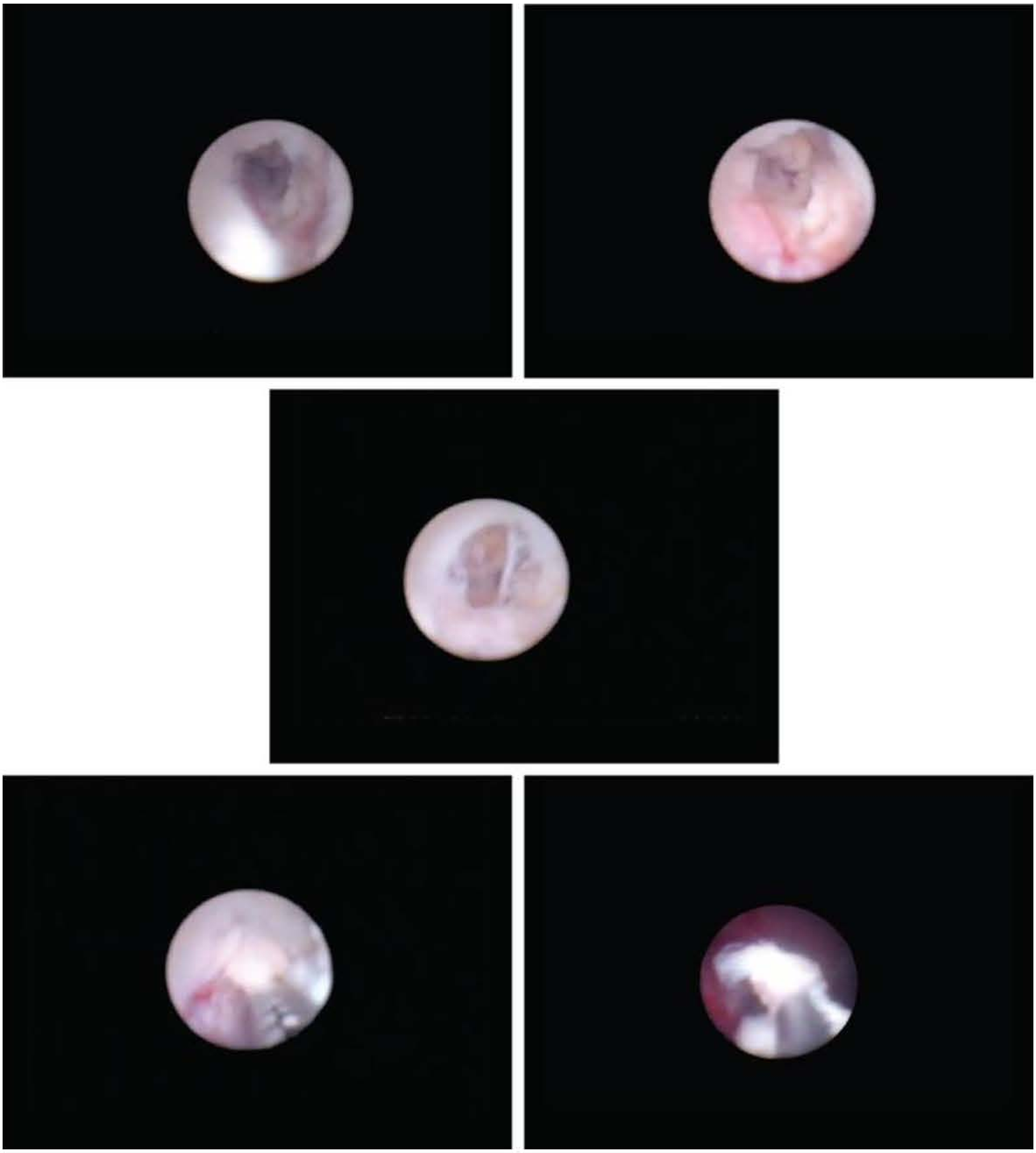


Figure 4.36 **Forceps biopsy of a stenosing ureteral tumoral mass.**

Biopsy may be followed by the complete removal of the lesion or hemostasis by electric or laser fulguration.

4.3.6.4. Biopsy Using the Basket Catheter

This method implies ascending an open basket catheter until the mass that is to be biopsied reaches between its spirals. After being partially closed, the basket is then slowly moved back and forth until the tissue becomes separated. The biopsy will be followed by the electric or laser fulguration of the area.

4.3.6.5. Electroresection

Through this method, the sampling of material for the anatomopathological exam is obtained by using a ureteroresectoscope (Fig. 4.37).

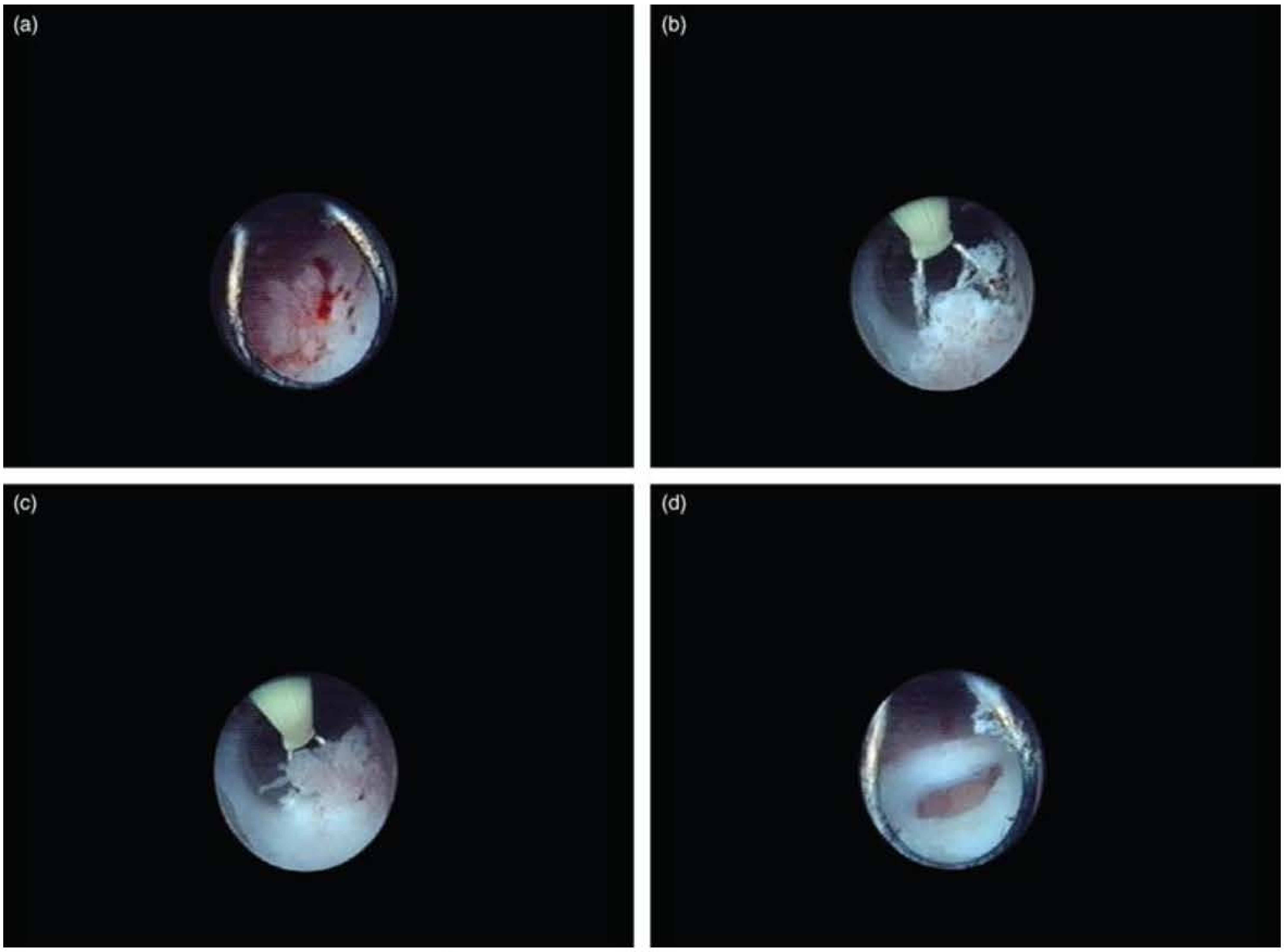


Figure 4.37 **Electroresection biopsy.**

Ureteral tumoral mass (a), electroresection of the tumoral mass (b, c), appearance of the ureteral wall at the end of the intervention (d).

Due to the reduced thickness of the urinary tract at this level, the risk of perforation is much higher compared to the electroresection of bladder lesions. In order to avoid complications, it is recommended to perform superficial resections, with the limitation of respiratory excursions at the moment of applying the electric current. Some authors recommend using this method only for lesions of the distal ureter, where the wall's thickness is greater (Su and Sosa, 2002).

A technical trick can be used for limiting the thermal injuries of the ureteral wall and of the adjacent tissues. After passing the lesion with the loop, the latter will be slowly withdrawn, pulling a part of the tissue into the resectoscope's sheath. The cutting current will be activated in this position in short bursts to detach the bioptic specimen (Su and Sosa, 2002).

Hemostasis is performed after removing the lesion, also with the help of the loop, but by applying a coagulation current. A ureteral stent will be placed at the end of the intervention.

Lesions with an aspect specific for hemangiomas (flat or protruding masses, of a red or bluish color, sometimes imprecisely demarcated, frequently located at the level of the renal papilla) contraindicate biopsy, due to the high risk of bleeding (Monga and Beeman, 2004), but can be treated immediately with electric fulguration or Ho:YAG laser (Tawfiek and Bagley, 1998). The Nd:YAG laser has excellent hemostasis properties, but its increased tissue penetrability requires caution in its use for this type of pathology.

Hemostasis of multifocal lesions may prove difficult and presents an important risk of recurrence. The association of pyelocaliceal instillations with 10 mL of 1% silver nitrate (Bahnson, 1987) or epsilon aminocaproic acid (150 mL/kg/day, in four equal doses) (Stefanini et al., 1990) has been proposed.

4.3.7. Ureteral Stenting

Routine postinterventional stenting is not recommended in patients in whom flexible ureteroscopes with a diameter below 9 F have been used, which do not require prior dilation of the intramural ureter for insertion and are much less traumatic for the urinary tract.

Tawfiek and Bagley report an intramural ureter dilation rate during flexible diagnostic ureteroscopy of 4.3% (Tawfiek and Bagley, 1998).

When required (after balloon catheter hydraulic dilation of the intramural ureter, after prolonged interventions, electroresection biopsy, etc.), the procedure ends with the placement of a ureteral JJ stent on the coiled guidewire, under fluoroscopic control.

A urethro-vesical catheter is placed for 12–24 h.

Usually, if there are no important parietal lesions of the upper urinary tract, the ureteral stent will be maintained for 2–3 days (Nakada et al., 1997).

Antibiotherapy must be continued for another 3–4 days after the procedure.

4.4. Incidents and complications

Minor complications are considered those without long-term effects and which minimally and transiently affect the urinary tract if promptly recognized and treated. Major complications are the result of excessive tissue trauma, which lead to perforations of the ureteral wall, avulsions, extraureteral migration of foreign bodies, etc.

The rate of complications, whether minor or major, decreases with the improvement of the ureteroscopy technique, with the increase in the operator's experience, and also as a consequence of following some essential principles: preoperative parenteral antibiotic prophylaxis, careful placement of guidewires, minimal ureteral dilation, ureteral stenting in selected cases. At the same time, technical progress has allowed for the permanent improvement of flexible instruments (Troy et al., 2004) by reducing size, introducing a second active deflection, and by the presence of design particularities that facilitate the insertion of the endoscope into the upper urinary tract and reduce tissue trauma (distal extremities of a smaller diameter than the sheath and with a bevel profile, etc.). As a consequence of combining all of these factors, in the last decade, a stable trend of reducing postureteroscopic incidents and complications has been registered in centers with experience in endourology.

By using flexible instruments, the rate of incidents and complications has decreased in patients with voluminous median lobe prostate adenoma, cystocele and genital prolapse, skeletal anomalies that prevent correct positioning, or other pathological modifications that usually hinder rigid endoscopy of the upper urinary tract.

A separate category of intraoperatory incidents is represented by iatrogenic lesions that, although minor in the vast majority of cases, may pose problems of differential diagnosis with preexisting lesions, making the diagnostic act more difficult. Thus, increased irrigation pressure may induce the appearance of erythematous areas, submucosal blood suffusions (Figs 4.38 and 4.39), or even bleeding at the level of the caliceal infundibulum and renal pelvis (Tawfiek and Bagley, 1998), the deflection of the flexible ureteroscope toward the lower calyx may produce lesions at the site of insertion of the caliceal infundibula into the renal pelvis (Dooley and Pietrow, 2004), while ascending the metallic guidewire may damage the caliceal papillae (Fig. 4.40).

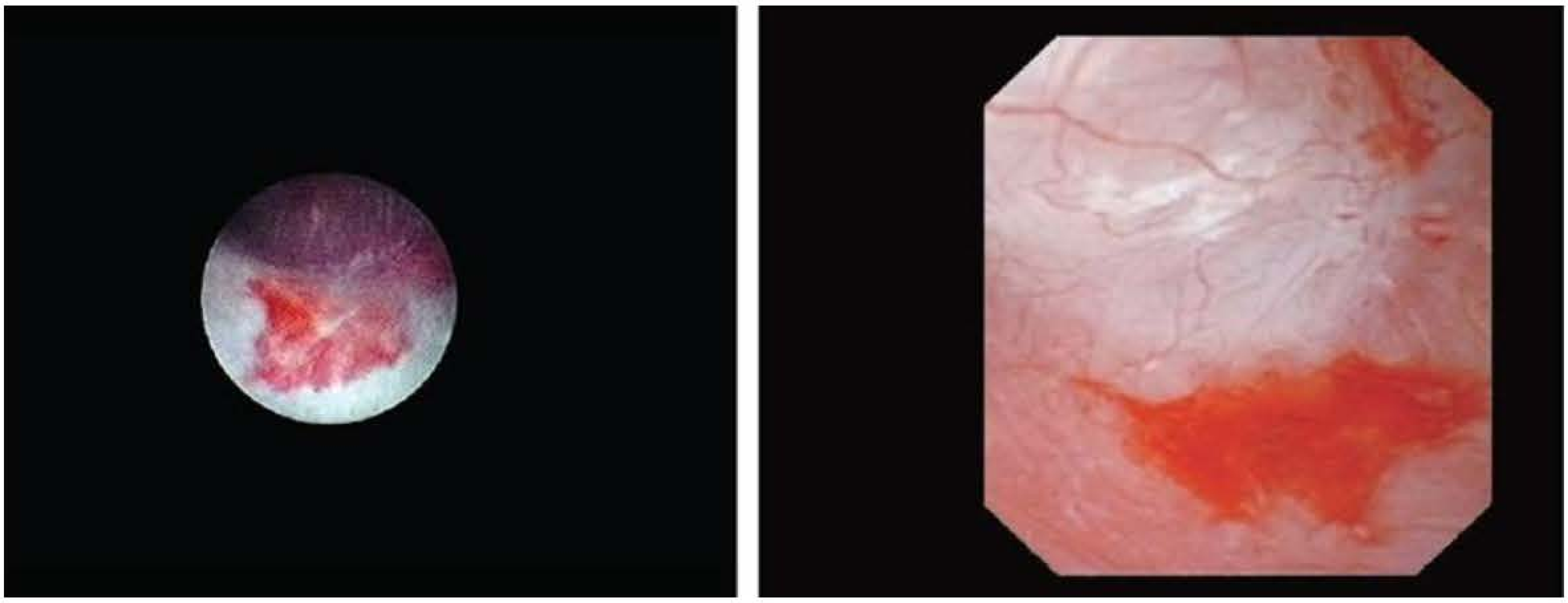


Figure 4.38 **Caliceal submucosal blood suffusions due to increased irrigation pressure.**

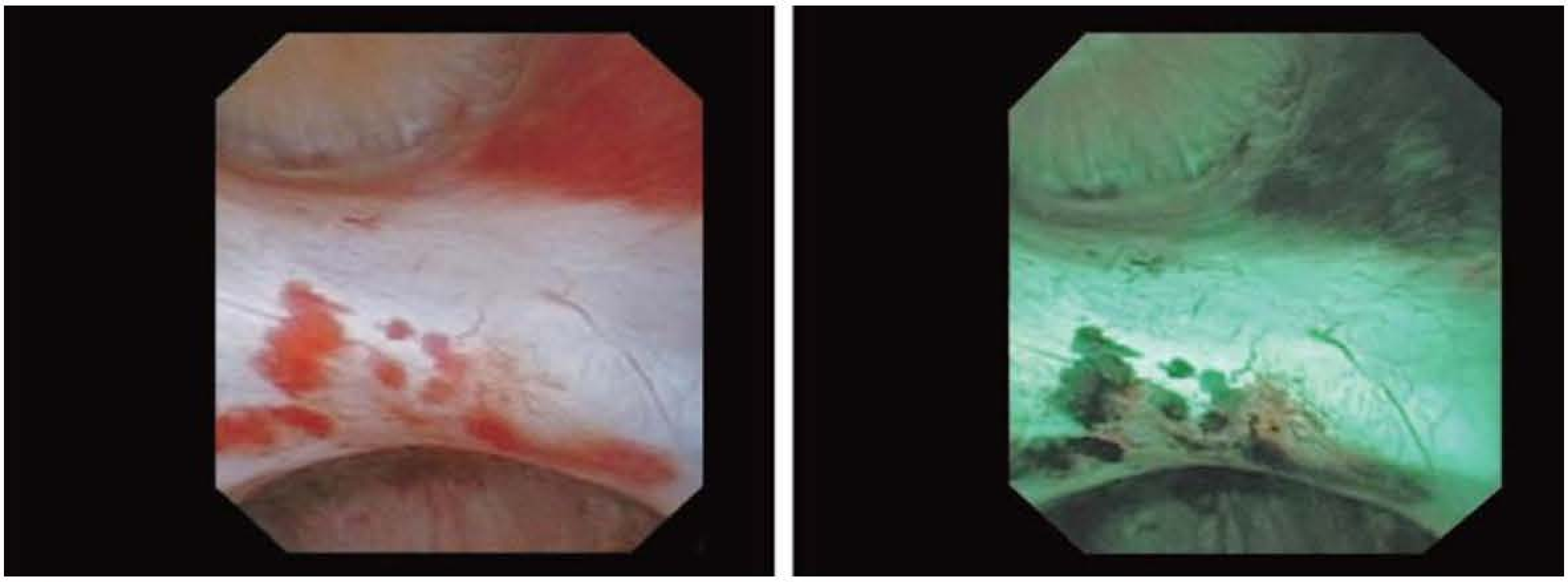


Figure 4.39 Blood suffusions determined by increased pressure of the irrigation fluid, without characters of malignant lesion under NBI inspection.

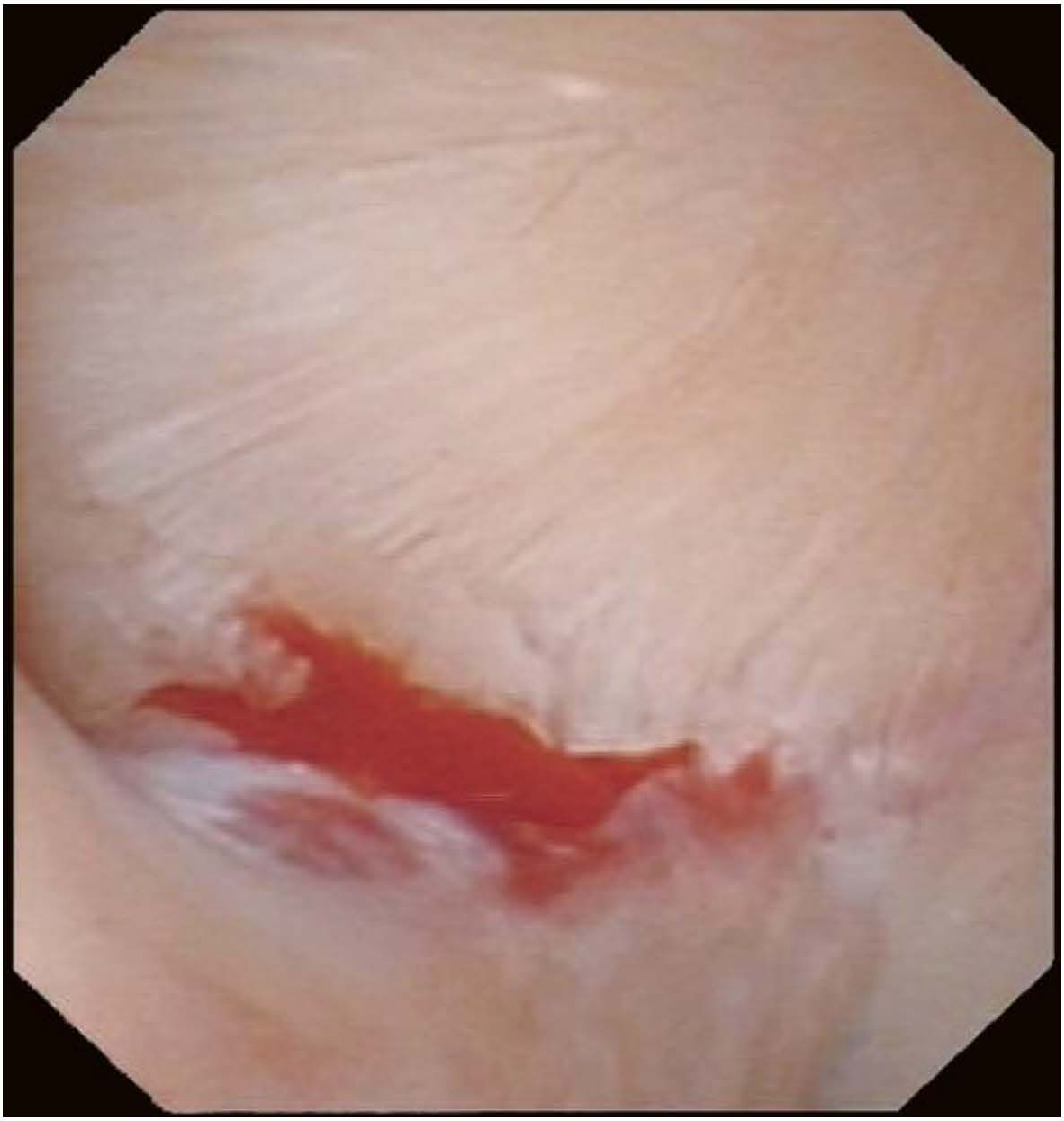


Figure 4.40 **Guidewire lesion at the periphery of a caliceal papilla.**

The use of a low pressure, manipulating the flexible endoscope under fluoroscopic control and maintaining the guidewire outside the pyelocaliceal system, most often allows these incidents to be avoided, with the purpose of establishing a precise diagnosis.

The complications most frequently reported after flexible diagnostic ureteropyeloscopy are rare and generally do not have significant repercussions on the upper urinary tract or on the body in general (Grasso and Bagley, 1998). These are represented by persistent hematuria, fever or chills, colicky pains caused by clot migration, acute pyelonephritis, iatrogenic ureteral perforations caused by the guidewire, or irrigation fluid leakage after balloon dilation of the narrowed uretero-pelvic junction. A ureteral JJ stent can be endoscopically placed in all of these situations, in order to limit the evolution of these complications.

Biopsy of suspect lesions may determine a series of complications: prolonged bleeding, perforations of the upper urinary tract (especially if electroresection is used).

Tumoral dissemination through pyelo-venous, pyelo-tubular, or pyelo-lymphatic reflux has been suggested due to irrigation, sometimes under high pressure, during ureteropyeloscopy, but studies have demonstrated that there are no long-term negative effects associated with this diagnostic procedure in patients who subsequently underwent a radical surgical treatment (Boorjian et al., 2005).

Thus, Kulp and Bagley studied a group of 13 patients with upper urinary tract transitional tumors diagnosed by ureteroscopy associated with biopsy and who subsequently underwent nephroureterectomy. At the anatomopathological exam of the specimens, the authors identified the presence of tumoral cells at the vascular/lymphatic level in a single case, in which extension was suspected before the endoscopic exploration due to the characteristics of tumor growth (Kulp and Bagley, 1994).

Similarly, Hendin, Streem, and Levis studied 96 patients with upper urinary tract urothelial tumors treated either by nephroureterectomy or by distal ureterectomy, with negative margins of the operatory specimen on the anatomopathological exam.

The patients were divided into a study group, in which preoperatory diagnostic ureteroscopy had been performed, and a control group, in which this investigation was not used: 12.5% of patients in the study group and 18.8% of the control group presented metastases. The 5-year survival without metastases was 0.67 in patients investigated ureteroscopically, compared to 0.71 for the others, while the global survival was 0.87, compared to 0.76. The lack of statistically significant differences between the two groups supports the clinical safety of this investigation (Hendin et al., 1999).

4.5. Results

The success of ureteroscopy in establishing a correct diagnosis is conditioned by the approach of the entire upper urinary tract.

The percentage of cases in which complete exploration of the upper urinary tract was possible varies between 66% and 95.7% in the published studies (Table 4.3).

Table 4.3

The Results of Diagnostic Ureteroscopy in Upper Urinary Tract Pathology

Authors	Number of procedures	Success rate (%)
Kumon et al. (1990)	12	83.3
Puppo (1991)	23	95.7
Elashry et al. (1997)	116	90.5
Nakada et al. (1997)	15	82
Tawfiek and Bagley (1998)	23	78.3
Yazaki et al. (1999)	15	66
Geavlete et al. (2006)	23	95.7

Among the factors that influence the success of the endoscopic approach are the anatomic particularities of the pyelocaliceal system (Bagley and Rittenberg, 1987), the performance of the flexible ureteroscope used (Bagley, 1993), and the type of accessory instruments necessary for an eventual biopsy, etc. Most frequently, the limitations are represented by the difficult access to the lower calyx (Monga and Beeman, 2004; Geavlete et al., 2007a and b).

The success rate of diagnostic flexible ureteroscopy in patients with unilateral hematuria varies between 78% and 83% (Bagley and Allen, 1990; Kumon et al., 1990; Tawfiek and Bagley, 1998; Geavlete et al., 2007a).

Using flexible endoscopes, Nakada and Clayman diagnosed and treated 17 patients with unilateral hematuria, detecting suggestive lesions in 82% of cases (focal in 64% and diffuse in 18%) (Nakada et al., 1997).

Similarly, Puppo identified suggestive lesions in 22 of the 23 patients from the studied group, proving the elective role of flexible ureteroscopy in the etiological diagnosis of hematuria originating in the upper urinary tract (Puppo, 1991).

Detection of a lesion requires treating it, endoscopically if possible, during the same procedure.

Daneshmand successfully applied endoscopic treatment by electric or laser fulguration in 14 of the 15 cases diagnosed with hematuria due to renal hemangiomas (Daneshmand and Huffman, 2002).

Nakada reports a success rate of 82% for the endoscopic treatment of patients with focal lesions. Still, all cases of diffuse multifocal lesions from the studied group presented recurrent bleeding (Nakada et al., 1997).

The difficulties of an efficient endoscopic treatment for bleeding multifocal pyelocaliceal lesions are constantly reported in the literature (Dooley and Pietrow, 2004), some authors recommending to associate a systemic treatment or instillations with hemostatic agents into the upper urinary tract.

Thus, Bahnson uses instillations into the pyelocaliceal system with 10 mL of 1% silver nitrate for the treatment of hematuria in patients with sickle cell disease. He reports the rapid (after 1–2 instillations) and durable (no recurrences in 13 months of follow-up) disappearance of bleeding in these patients (Bahnson, 1987).

Bagley and Allen described a phenomenon of sudden cessation of hematuria following the endoscopic exploration procedure, possible explications being the pressure exerted by the irrigation or the postureteroscopy inflammation (Bagley and Allen, 1990).

An important aspect in evaluating the success of diagnostic ureteroscopy is represented by the ability of biopsies to allow for a correct identification of the stage and differentiation of malignant lesions.

Guarnizo, ureteroscopically performing 40 multiple "cold-cup" biopsies of upper urinary tract urothelial tumors, identified the correct grading in 78% of cases (Guarnizo et al., 2000).

By combining multiple and exfoliative biopsy, Skolarikos reported an increase in the specificity and sensitivity of detecting G3 tumors from 23% to 85% and from 43% to 55%, respectively (Skolarikos et al., 2003).

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Chapter 5

Abstract

Although it was initially introduced as an extension of cystoscopy, ureteroscopy has become an important technique in treating upper urinary tract disorders. Its progress was based on the development of rigid and flexible ureteroscopes, as well as of appropriate accessory instruments.

Keywords

upper urinary tract
ureteroscopic approach
extracorporeal lithotripsy
SWL

Although it was initially introduced as an extension of cystoscopy, ureteroscopy has become an important technique in treating upper urinary tract disorders. Its progress was based on the development of rigid and flexible ureteroscopes, as well as of appropriate accessory instruments.

Initially, the endoscopic ureteral approach was performed by using pediatric cystoscopes (Goodman, 1977). Its constraints were obvious, requiring the development of specific instruments, which would allow an easy approach to the upper urinary tract, including the pyelocaliceal system. It was not until the late 1970s that rigid ureteroscopy became a common urological practice. Subsequently, there has been a continuous evolution in terms of developing rigid, semirigid, or flexible small diameter ureteroscopes, which has led to the improvement of the ureteroscopic approach. These continuous advances naturally led to diversification regarding the indications for the retrograde approach of the upper urinary

5.1. Indications for therapeutic retrograde ureteroscopy

The modern indications for therapeutic retrograde ureteroscopic approach can be summarized as follows (Geavlete et al., 2003b):

- extraction of ureteral calculi regardless of their location (Geavlete et al., 1998, 2004b)
- treatment of pyelocaliceal lithiasis (in selected cases)
- treatment of the steinstrasse syndrome after extracorporeal lithotripsy
- endoscopic treatment of superficial tumors of the upper urothelial field (in selected cases) (Geavlete et al., 2003a)
- endoscopic treatment of symptomatic caliceal diverticula and of intradiverticular lithiasis (in selected cases) (Geavlete et al., 2004b)
- endoscopic treatment of intrinsic or extrinsic ureteral stenoses, benign or malignant (Geavlete et al., 2000, 2002b,c, 2003d)
- endoscopic treatment of stenoses of the pyeloureteral junction, congenital or acquired (Geavlete et al., 2001, 2002a, 2003c)
- extraction of intraureteral foreign bodies
- treatment of iatrogenic ureteral lesions

The treatment of upper urinary tract stones is the most important indication of retrograde ureteroscopy.

It is likely that the modern urologist's major dilemma is choosing between the most commonly used therapeutic methods: extracorporeal lithotripsy (SWL) and ureteroscopy. The progress regarding the design of ureteroscopes, as well as the evolution of extracorporeal lithotripsy, has changed the balance between the indications for these methods of treatment in ureteral lithiasis.

According to the guideline of the European Association of Urology (EAU), the therapeutic indications for ureteral lithiasis are differentiated by location, size, degree of obstruction, chemical composition, and potential association of infection (Tables 5.1–5.4).

Table 5.1

Principles of Interventional Treatment in Calculi of the Proximal Ureter According to EAU Urolithiasis Panel (2006)

Radiopaque calculi	1. SWL *in situ* 2. SWL after ascending the calculus (push up) 3. Antegrade ureteroscopy with percutaneous transrenal approach 4. Retrograde ureteroscopy with contact destruction a. with semirigid ureteroscope b. with flexible ureteroscope
Calculi complicated with infection	1. Antibiotherapy + SWL *in situ* 2. Antibiotherapy + SWL after ascending the calculus (push up) 3. Antibiotherapy + percutaneous nephrolithotomy + antegrade ureteroscopy 4. Antibiotherapy + retrograde ureteroscopy with contact destruction a. with semirigid ureteroscope b. with flexible ureteroscope
Uric acid calculi	1. Stent + oral chemolysis 2. SWL *in situ* + oral chemolysis 3. Antegrade ureteroscopy 4. Retrograde ureteroscopy with contact lithotripsy a. with semirigid ureteroscope b. with flexible ureteroscope
Cystine calculi	1. SWL *in situ* 2. SWL after ascending the calculus (push up) 3. Antegrade ureteroscopy with percutaneous transrenal approach 4. Retrograde ureteroscopy with contact destruction a. with semirigid ureteroscope b. with flexible ureteroscope

Table 5.2

Principles of Interventional Treatment in Calculi of the Middle Ureter According to the EAU Urolithiasis Panel (2006)

Radiopaque calculi	1. SWL *in situ* 2. Retrograde ureteroscopy + contact destruction a. with semirigid ureteroscope b. with flexible ureteroscope 3. Ureteral catheter or intravenous contrast media + SWL 4. Ureteral catheter with ascent of the calculus + SWL 5. Antegrade ureteroscopy with percutaneous transrenal approach
Calculi complicated with infection	1. Antibiotherapy+ SWL *in situ* 2. Antibiotherapy + retrograde ureteroscopy with contact destruction a. with semirigid ureteroscope b. with flexible ureteroscope 3. Ureteral catheter or intravenous contrast media + SWL 4. Ureteral catheter with ascent of the calculus + SWL 5. Stent + oral chemolysis 6. Antegrade ureteroscopy with percutaneous transrenal approach
Uric acid calculi	1. SWL *in situ* 2. Retrograde ureteroscopy + contact destruction with semirigid or flexible ureteroscope 3. Ureteral catheter or intravenous contrast media + SWL 4. Ureteral catheter with ascent of the calculus + SWL 5. Stent + oral chemolysis 6. Antegrade ureteroscopy with percutaneous transrenal approach
Cystine calculi	1. SWL *in situ* 2. Retrograde ureteroscopy with contact destruction with semirigid or flexible ureteroscope 3. Ureteral catheter with ascent of the calculus + SWL 4. Stent + oral chemolysis 5. Antegrade ureteroscopy with percutaneous transrenal approach

Table 5.3

Principles of Interventional Treatment in Calculi of the Distal Ureter According to the EAU Urolithiasis Panel (2006)

Radiopaque calculi	1. SWL *in situ* 2. Retrograde ureteroscopy with contact destruction a. with rigid ureteroscope + ultrasonic (US) or laser lithotripsy or electrohydraulic disintegration b. with semirigid ureteroscope 3. Ureteral catheter + SWL
Calculi complicated with infection	1. Antibiotherapy + SWL *in situ* 2. Antibiotherapy + retrograde ureteroscopy with contact destruction 3. Antibiotherapy + percutaneous nephrostomy + SWL *in situ* 4. Antibiotherapy + ureteral catheter + SWL
Uric acid calculi	1. SWL *in situ* 2. Retrograde ureteroscopy with contact destruction 3. Ureteral catheter (+ contrast medium) + SWL 4. Percutaneous nephrostomy + antegrade contrast medium + SWL *in situ*
Cystine calculi	1. SWL *in situ* 2. Retrograde ureteroscopy with contact destruction

	a. with rigid ureteroscope + US or laser lithotripsy or electrohydraulic disintegration b. with semirigid ureteroscope 3. Ureteral catheter + SWL

Table 5.4

Therapeutic Recommendations for Steinstrasse According to the EAU Urolithiasis Panel (2006)

	Without obstruction	Obstruction and/or existing symptomatology
Proximal ureter	1. SWL	1. Percutaneous nephrostomy 2. Stent 3. SWL
Middle ureter	1. SWL	1. Percutaneous nephrostomy 2. Stent 3. SWL
Distal ureter	1. SWL 2. Retrograde ureteroscopy	1. Percutaneous nephrostomy 2. Stent 3. Retrograde ureteroscopy

The re-evaluation of data available in recent meta-analyses in 2007 led to a consensus between the European and American Urological Associations (EAU/AUA).

According to this consensus, spontaneous elimination of the calculus through pharmacological treatment can be considered a first-line option for ureteral stones smaller than 10 mm with symptoms that can be controlled therapeutically.

The success rate of spontaneous elimination, according to the meta-analyses, is of approximately 68% for calculi smaller than 5 mm and of 47% for those with sizes between 5 mm and 10 mm.

Patients for whom this therapeutic alternative is selected should not present signs of sepsis. They should also have an adequate renal functional reserve and it should be possible for their symptoms to be controlled by pharmacological treatment. These patients should be monitored regularly, active removal of the calculus being recommended in case of persistent obstruction, of colicky pains refractory to treatment, or of the absence of calculus progression.

For calculi larger than 10 mm, the first-line treatment is interventional, both SWL and ureteroscopy being viable alternatives. Patients should be informed about the benefits and risks of each method. A number of parameters must be taken into account when choosing one alternative or another: the “stone-free” rate, the type of anesthesia required, any auxiliary procedures, as well as the risk of complications. The “stone-free” rate is, in turn, dependent on several factors, including the location, size, and chemical structure of the calculi (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

The semirigid ureteroscopic approach of distal ureteral lithiasis ensures a success rate of almost 100%, this method being almost unanimously considered as the first therapeutic option. Although the success rates of semirigid ureteroscopy for middle and proximal ureteral calculi are lower, the introduction of flexible instruments has increased the success rate to over 90%. This has recently caused the balance to tilt in favor of ureteroscopy in the detriment of SWL. The introduction of modern methods of lithotripsy, especially the Ho:YAG laser, has contributed significantly to this development.

The development of flexible ureteroscopes has allowed the indications of retrograde approach to include pyelocaliceal lithiasis (Table 5.5). Although these flexible ureteroscopes, together with the new sources of lithotripsy, theoretically allow treatment regardless of size and location, the best results have been recorded in the approach of calculi smaller than 2 cm. Even in these cases, calculi located in the middle or upper calyces may benefit from extracorporeal lithotripsy as a first-line alternative. Lower caliceal lithiasis respresents an elective indication for retrograde flexible approach.

Table 5.5

Indications of Retrograde Flexible Ureteroscopy in the Treatment of Lithiasis of the Upper Urinary Tract(Bagley et al., 1987; Fuchs and Fuchs, 1990; Busby and Low, 2004)

Single or multiple ureteral, pyelic, and/or caliceal lithiasis
Endoscopic alternative in cases in which retrograde rigid ureteroscopy cannot be performed (urinary derivations,

etc.)

Endoscopic alternative in cases in which extracorporeal lithotripsy, percutaneous nephrolithotomy, or retrograde rigid ureteroscopy are contraindicated

Removal of lithiasic fragments remaining after SWL or PNL, or of calculi that ascended during rigid or semirigid retrograde ureteroscopy

Intradiverticular lithiasis allowing concomitant treatment of the caliceal diverticula

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The progress regarding ureteroscopic instruments, especially the development of miniaturized and flexible endoscopes, has allowed this method to also be used safely in pregnant women. This indication is even more important as the alternative, SWL, is contraindicated in this category of patients (Buchholz et al., 1998).

By improving accessibility in the entire upper urinary tract, it has become possible to perform retrograde ureteroscopy in an increasing number of patients with urinary malformations or derivations.

Regarding pyelocaliceal diverticula, there is currently a wide range of surgical options available for the treatment of this pathology: open interventions, retrograde ureterorenoscopic approach (Batter and Dretler, 1997; Baldwin et al., 1998), direct and indirect percutaneous approach (Shalhav et al., 1998; Geavlete et al., 2007; Kontak et al., 2007), or laparoscopic approach (Ruckle and Segura, 1994; Wong and Zimmerman, 2005). The indications of retrograde ureteroscopy are limited to symptomatic diverticula, smaller than 1.5 cm, with or without intradiverticular stones (Monga and Beeman, 2004), and especially for those positioned anteriorly, difficult to approach percutaneously (Leveille and Bird, 2007).

For tumors of the upper urinary tract, the "gold standard" of treatment is represented by nephroureterectomy with perimeatal cystectomy. However, due to technological progress, ureteroscopic approach may represent a viable therapeutic option in particular situations (Table 5.6).

Table 5.6

Indications of Endoscopic Treatment in Urothelial Tumors of the Upper Urinary Tract (Gaboardi et al., 1994; Chen and Bagley, 2000; Geavlete et al., 2004a, 2005)

Accepted indications	• small kidney • renal insufficiency (compromised renal function) • bilateral tumors	• single tumor • small dimensions (1.5–2 cm) • noninvasive tumor (Ta/T1; G1)
Controversial indications	• small tumor with normal contralateral kidney • multiple tumors • operatory risk (laparoscopic approach) • invasive tumor (high grade: G2–3) on single kidney	
Contraindications	• nonresectable tumor • high-grade tumor • invasive tumor • noncompliant patient	

All symptomatic patients or those with obstruction due to benign ureteral stenosis present an operatory indication in order to preserve renal function.

Open surgical techniques used for the treatment of ureteral strictures (ureteroneocystostomy, kidney mobilization, Boari flap, transureteroureterostomy, bowel interposition, renal autotransplant, nephrectomy) involve abdominal interventions (some major) that are associated with high morbidity and with prolonged hospitalization and social reintegration.

The indications of ureteroscopic approach of ureteral stenoses can be summarized as follows:

- benign inflammatory ureteral stenoses

- iatrogenic ureteral stenoses
- ureteral stenoses under 2 cm

For the treatment of ureteral stenoses by endoscopic approach, the following can be used: cold-knife incision, electroincision, Acucise balloon, balloon dilator, and, more recently, laser.

The technical method of application is individualized according to the characteristics of each case (Fig. 5.1). Regarding the indications of using metallic ureteral stents, these are not yet fully systematized, most authors recommending positioning this type of stent in both malignant and benign ureteral stenoses.

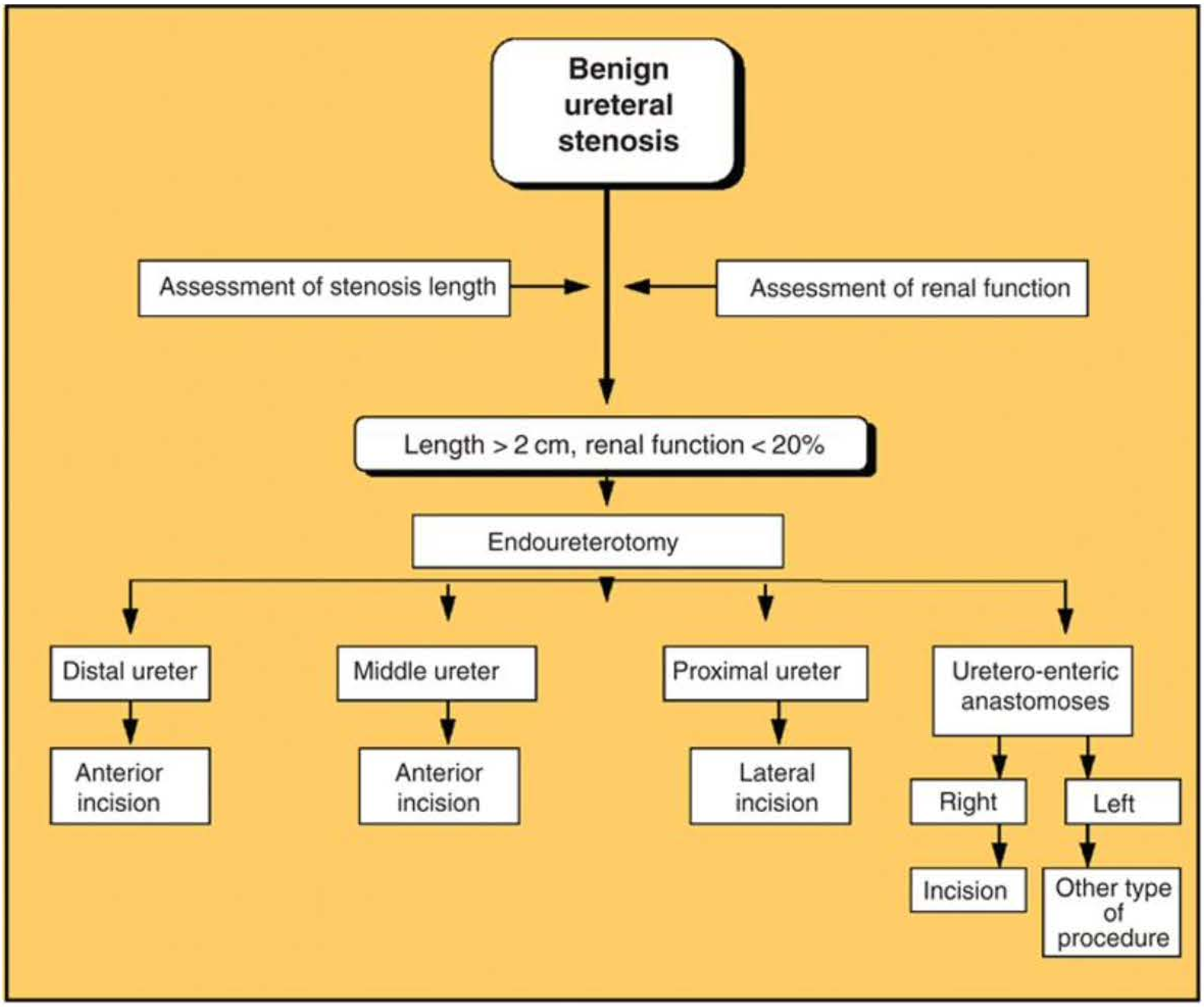
Benign ureteral stenosis
Assessment of stenosis length
Assessment of renal function
Length > 2 cm, renal function < 20%
Endoureterotomy
Distal ureter
Middle ureter
Proximal ureter
Uretero-enteric anastomoses
Anterior incision
Anterior incision
Lateral incision
Right
Left
Incision
Other type of procedure

Figure 5.1 **The algorithm for the retrograde endoscopic treatment of ureteral stenoses.**

The treatment of ureteropelvic junction stenosis is imposed by the presence of symptoms associated with the obstruction, the progressive deterioration of the ipsilateral or even global renal function, the association of lithiasis, of urinary infection or, in rare cases, of arterial hypertension.

Although, theoretically, retrograde ureteroscopic approach can be used in most cases with ureteropelvic junction stenosis, achieving optimal success rates depends on a careful selection of cases. Thus, the presence of negative predictive factors such as preoperative renal function <20%, increased stenosis length, and association of polar vessels or of severe hydronephrosis indicate that other therapeutic modalities should be used. Other circumstances that would contraindicate retrograde endoscopic approach are represented by the association of renal lithiasis (and especially the voluminous one, which more readily benefits from percutaneous treatment) or by the high insertion of the ureter at the pyelic level (the latter being a controversial negative predictive factor).

Antegrade ureteroscopy has limited indications, usually being reserved for cases with very difficult or impossible retrograde approach, or in those in which it completes the percutaneous approach of some pyelocaliceal injuries.

Technological progress, especially the introduction of flexible ureteroscopes and of modern power sources, has allowed the diversification of the indications for retrograde approach to also include certain particular situations (pregnant women, children, patients with malformations of the upper urinary tract, etc.).

5.2. Limitations of rigid and semirigid ureteroscopy

The limitations of rigid and semirigid ureteroscopes derive from their reduced degree of elastic deformation and from their relatively increased diameter.

Thus, the advantages of a working channel that allows the use of a wide range of accessory instruments, superior visibility and reliability, or ease of handling in the distal region of the upper urinary tract are offset by limited access to the pyelocaliceal system and, sometimes, even to the ureter.

The use of rigid ureteroscopes with an increased diameter requires, in a significant percentage of cases, the dilation of the ureteral orifice. This method usually implies post-procedure stenting and, implicitly, an increase in associated morbidity. The coexistence of pathological changes (cystocel, voluminous prostate adenoma, etc.) may limit rigid retrograde access to the pelvic ureter.

Reno-ureteral malformations, stenosis, or important bends may prevent the ascent of the (semi)rigid endoscopes at different levels of the upper urinary tract.

Limiting access to the entire pyelocaliceal system may require interrupting the intervention in certain circumstances (e.g., ascending migration of a proximal ureteral stone).

The physical characteristics of rigid ureteroscopes (especially those of high caliber), as well as the use of more robust accessory instruments, is associated with an increased incidence of upper urinary tract traumatic complications.

Despite the continuous efforts to overcome these obstacles by improving the semirigid endoscopes (miniaturization, introduction of digital optical systems, etc.), the development of flexible ureteroscopes seems to offer, at least in perspective, much more efficient and versatile

5.3. Limitations of flexible ureteroscopy

5.3.1. The Fragility and Increased Cost of Instruments

Flexible ureteroscopes are expensive endoscopes compared to their rigid or semirigid counterparts. In addition, this method requires the use of certain types of accessory instruments or energy sources for lithotripsy (flexible, with a low caliber in order to be inserted into the working channel, etc.), which in turn contribute to the increased costs of flexible ureteroscopy.

The miniaturization of flexible ureteroscopes, with the purpose of reducing operatory trauma on the urinary tract, has unfortunately resulted in their increased fragility. The low caliber, the existence of the deflection system, and the insertion of instruments into a working channel that is not straight, all create the conditions for damaging these endoscopes.

Some of the most common causes of destruction of flexible ureteroscopes are represented by the accidental discharge of the laser fibers in the working channel, perforation as a result of the insertion of accessory instruments, or excessive twisting. Laser fibers are the accessories with the greatest potential for damaging the working channel. Seto and Ishiura evaluated this effect in an *in vitro* study that involved inserting various accessory instruments 100 times through the endoscope with 0, 30, 60, 90, and 120° deflections. The occurrence and severity of potential injuries were subsequently determined by testing the tightness of the working channel and evaluating its internal surface with a small caliber fiberscope. Thus, the repeated insertion of 3 F forceps or of 2.4 F basket catheters produced no significant damage, regardless of the deflection angle. Fiberscopic assessment of the internal surface of the working channel after inserting 200 and 250 µm laser fibers revealed minor abrasions for angles of 0 and 30° and deep imprinting for deflections of 60 and 90°. Advancing laser fibers into the working channel of the ureteroscope with a 120° deflection was not possible nor produced perforations (Seto et al., 2006).

Even when used carefully, avoiding the accidents presented earlier, a phenomenon of "fatigue" has been described in flexible ureteroscopes, with their performance steadily decreasing over time.

Older models had a period of functioning of approximately 3–13 h or 6–15 uses before requiring repairs, the reduction of the maximum amplitude of active deflection being the problem that occurred most frequently, especially after interventions that required a prolonged approach of the lower caliceal group (Busby and Low, 2004).

In a study conducted with four 7.5 F flexible ureteroscopes, an average number of 50.3 passages was reported (varying between 42 and 66) until losing 25° of deflection (Pietrow et al., 2002).

Despite technological progress, this phenomenon continues to appear, although more slowly, in new-generation flexible ureteroscopes. Traxer and coworkers evaluated a Storz 11278 AU1 Flex-X flexible ureteroscope; after a number of 50 procedures consisting of a total of 17 h and 15 min, the authors registered a decrease of the maximal ventral deflection from 270° to 208°, of the maximal dorsal deflection from 270° to 133°, and of the flow of the irrigation fluid at a pressure of 100 cm H_2O from 50 mL/min to 40 mL/min (Traxer et al., 2006).

Monga and coworkers in a prospective and randomized trial evaluated the durability of seven models of flexible ureteroscopes: Storz 11274AA and Flex-X, ACMI DUR-8 and DUR-8 Elite, Wolf 7330.170 and 7325.172, respectively Olympus URF-P3. According to the results of this study, the ACMI DUR-8 Elite and Olympus URF-P3 models appear to have superior resistance. Thus, the longest functioning period without repair (494 min) was registered for the DUR-8 Elite model, the longest period of lower caliceal approach was registered for the URF-P3, while both models presented the longest working period with inserted accessory instruments (Monga et al., 2006).

Another problem is represented by the fracturing of the fibers that compose the optical system of conventional flexible ureteroscopes. Each broken fiber generates a black dot in the endoscopic field (Fig. 5.2), and when there is a significant number of these, they can alter visibility, preventing the interventions from being carried out in good conditions.

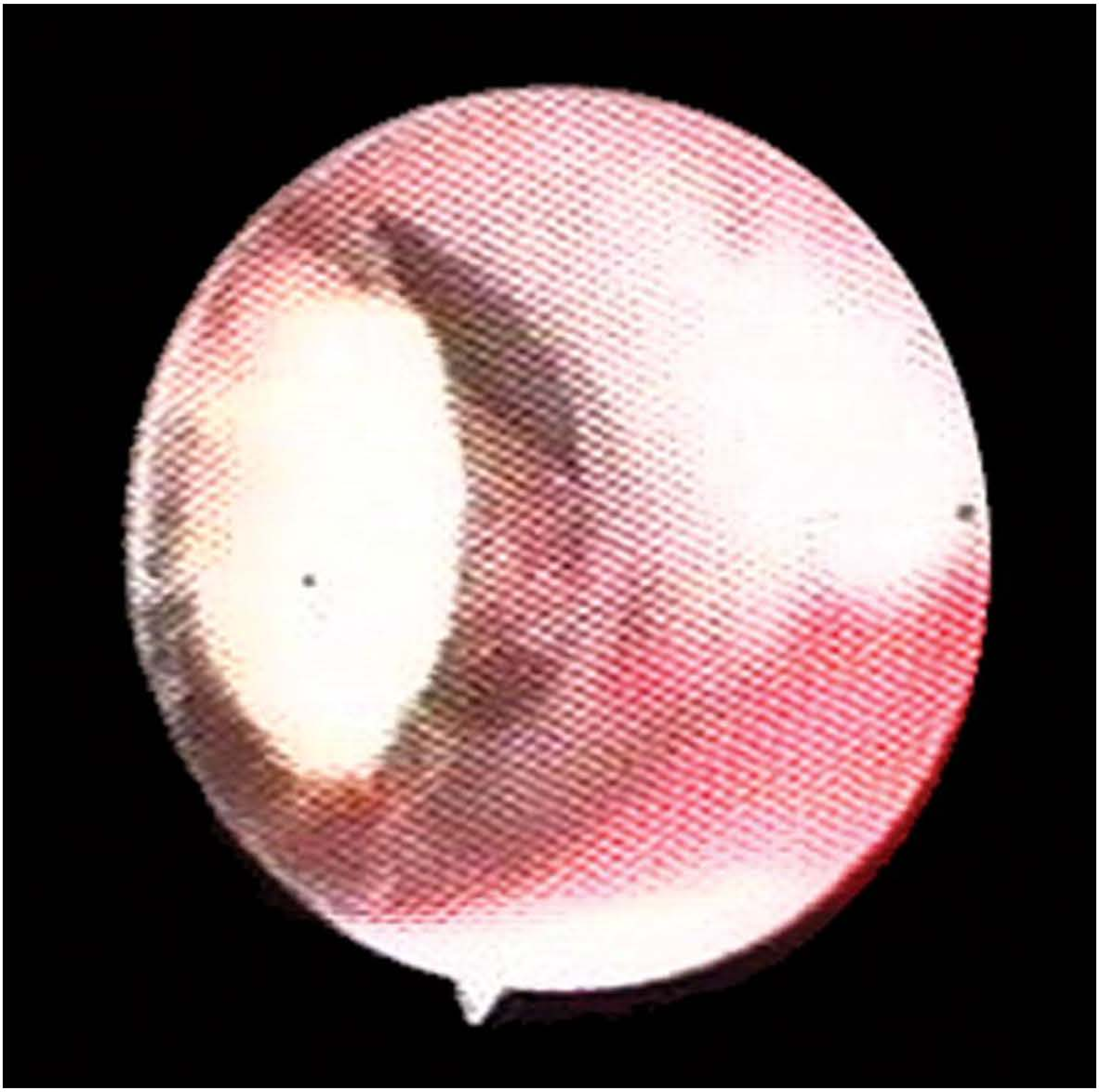

Figure 5.2 **Flexible ureteroscope with two broken optic fibers, generating black dots in the endoscopic field.**

Assessing four older models of flexible ureteroscopes, Pietrow and coworkers reported an average of 15.3 passages (varying between 12 and 20) until the breaking of over 20 optical fibers was recorded (Pietrow et al., 2002). In order to extend the lifespan of the optical system, it is recommended to avoid any external trauma to the working region of the flexible ureteroscope, as well as excessive torsioning or bending.

The optical systems of the latest-generation conventional flexible ureteroscopes seem to have superior durability; Traxer reported only six broken fibers after 50 procedures with the Storz Flex-X model (Traxer et al., 2006). In the case of the new models of digital flexible ureteroscopes, the fragile optical fiber system has been removed, the image being transmitted from the distal sensor to a proximal processor through a single wire.

The great variability regarding the results of durability studies indicates the influence of various factors (related to the operator, handling and storage conditions, the treated pathology, etc.) on this phenomenon. When adequately handled, the new generation of ureteroscopes, although still having a high potential for being damaged, presents a superior durability, offering a greater number of hours of use before requiring repairs, compared to previous models.

Different methods and technical artifices have been studied and devised in order to prolong the functioning period of flexible ureteroscopes. Thus, the routine use of nitinol accessory instruments, with an increased flexibility, which are less demanding on the deflection mechanism, has been proposed (Pietrow et al., 2002). In addition, these present a reduced aggressiveness on tissues and superior durability.

Also, some authors believe that the routine use of the ureteral access sheath reduces the aggression on flexible ureteroscopes, the operating time, and the costs of the interventions (Kourambas et al., 2001).

In order to protect the working channel, advancing the 200 µm laser fiber through a previously inserted 2 F catheter has been proposed. Although the flexible ureteroscope's deflection does not seem to be diminished by the insertion of this catheter, the flow of the irrigation fluid is reduced (Seto et al., 2006).

The application of a ceramic protective layer on the distal region of the new models of ureteroscopes is part of the effort to prolong the working period of flexible endoscopes. Thus, the Storz 11278AU1 Flex-X presents a layer of Laserite™ ceramic material on a 1.5 cm distal part of the working channel, which has the role of protecting the area from accidental discharges of the laser fibers and of allowing lithotripsy in the immediate proximity of the endoscope. Similarly, the Olympus URF-P5 model presents a ceramic piece in the distal part, with a protective role during electrohydraulic lithotripsy. In order to prevent the fatigue phenomenon, it is recommended to limit the working period at the level of the lower calyx. For this purpose, the displacement of calculi at this level and their fragmentation in the renal pelvis will be preferred instead of *in situ* lithotripsy (Pasqui et al., 2004).

5.3.2. Reduced Visibility

Visibility during flexible ureteroscopy is reduced, compared with rigid or semirigid endoscopic interventions. This phenomenon is the result of several factors:

- small size of the endoscopic field
- poor image resolution
- low irrigation flow
- lack of clarity of the pyelocaliceal environment (hematuria, pyuria)

The miniaturization of flexible ureteroscopes has imposed the reduction of the dimensions of the optical systems and of the working channel, with direct implications on intraoperative visibility (Fig. 5.3).

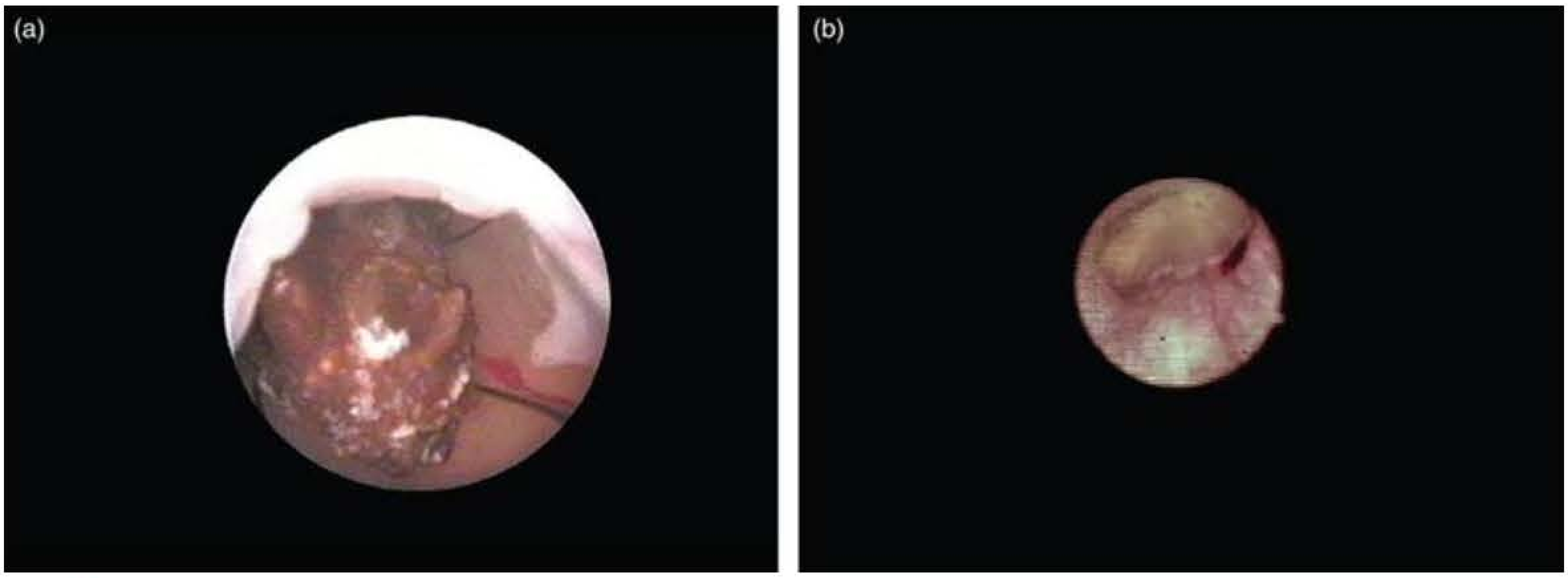

Figure 5.3 **The differences regarding the area and resolution of the endoscopic field between the optical systems of a semirigid ureteroscope (a) and a conventional flexible one (b).**

The currently used conventional flexible ureteroscopes generally have an endoscopic visual field area of 20–22 cm². An exception is represented by the Olympus URF-P3 model, which has the widest endoscopic field, measuring 25 cm² (Parkin et al., 2002).

Conventional models have optical systems consisting of a coherent beam of glass fibers. This structure generates the previously described images with a honeycomb aspect (or moire effect), with a lower resolution than that obtained by the optical systems of rigid or semirigid ureteroscopes. The flow of the irrigation fluid is one of the essential parameters of obtaining sufficient visibility for performing endoscopic interventions in good conditions. Most flexible ureteroscopes in use today have a working channel of 3.6 F, providing a reduced irrigation flow compared to the rigid or semirigid models.

The Wolf 7330.072 flexible ureteroscope has a 4 F working channel, allowing an increased flow of the irrigation fluid, which leads to better visibility, but with the disadvantage of a higher caliber of 9 F at its tip.

The insertion of the various accessory instruments, probes, or lithotripsy fibers into the working channel further reduces the irrigation flow (Table 5.7). There is a correlation between the dimensions of the instruments used and the reduction of the irrigation flow.

Table 5.7

Variation of the Irrigation Fluid Flow according to the Accessory Instruments Inserted in the Working Channel of Different Models of Flexible Ureteroscopes (Pasqui et al., 2004; Parkin et al., 2002)

Model	Irrigation pressure (cm H_2O)	Empty channel	Laser fibers		EHL probes		Forceps and catheters	
			200 µm	**365 µm**	**1.6 F**	**1.9 F**	**2.4 F**	**3 F**
ACMI DUR-8 Elite	60	42	28	18	23	18	8	4
	100	54	38	23	26	26	11	6
	130	88	44	36	–	34	–	–
Olympus URF/P-3	60	36	21	13	16	11	5	2
	100	46	29	18	24	15	6	3
	130	72	53	32	–	52	–	–
Storz 11274AA	60	46	24	16	16	14	6	5
	100	56	32	18	24	16	7	6
	130	74	42	31	–	32	–	–
Storz 11278AU1	60	40	21	14	16	12	4	3
	100	48	28	18	18	15	5	6
	130	–	–	–	–	–	–	–
Wolf 7330.072	60	–	–	–	–	–	–	–
	100	–	–	–	–	–	–	–
	130	116	72	58	–	56	–	6
Wolf 7325.172	60	44	25	19	16	14	6	3
	100	54	30	22	24	18	8	5
	130	–	–	–	–	–	–	–

This effect can be partially compensated for during the intervention by using irrigation under pressure (Table 5.7). Several methods have been described by which this can be obtained: increasing the height from which the bags are suspended, manually applying pressure on them, the use of specially designed devices (such as the Uromat), etc.

Even under these conditions, the insertion of high-caliber instruments (2.4–3 F) into the working channel determines a decrease of the irrigation flow to negligible values, regardless of the pressure under which irrigation is performed (Parkin et al., 2002; Pasqui et al., 2004).

A phenomenon described in the literature, yet difficult to explain, is the variable influence of accessory instruments of the same caliber produced by different companies on this parameter (Pasqui et al., 2004).

Under these circumstances, further alteration of the clarity of the pyelocaliceal environment (pyuria, preexisting hematuria, or secondary to the surgical trauma) may prevent performing the intervention in good conditions or may even require interrupting the procedure.

Digital flexible ureteroscopes have the advantage of a wide endoscopic field, with an image resolution superior even to that of rigid or semirigid models (Fig. 5.4). Although the other parameters that influence visibility (irrigation fluid flow, the influence of accessory instruments, etc.) are similar to conventional ureteroscopes, the progress in solving this limitation is obvious.

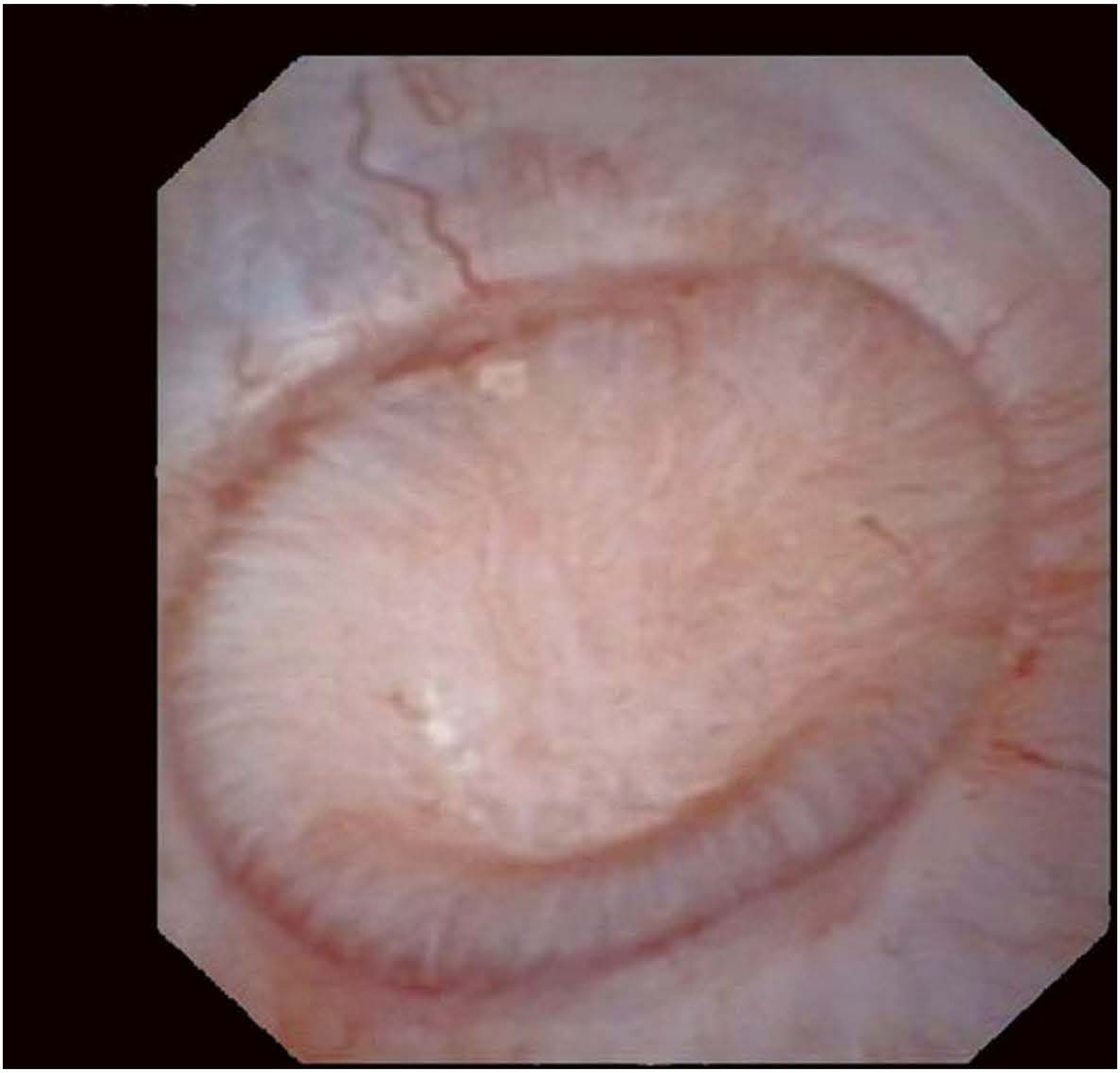

Figure 5.4 **Superior image resolution characteristic for digital flexible ureteroscopes.**

5.3.3. The Difficulties in Approaching Some Regions of the Pyelocaliceal System

Flexible ureteroscopy theoretically allows for the retrograde approach of the entire upper urinary tract. However, in practice, the access to some regions of the pyelocaliceal system may prove difficult or even impossible.

Such problems occur most frequently when trying to approach the lower caliceal group. There are a number of factors that condition the access to this level:

- anatomy of the pyelocaliceal system
- the presence of pathological changes (hydronephrosis, stenoses, etc.)
- deflection capacity of the flexible ureteroscope

Some anatomical parameters of the lower caliceal group have been associated with low success rates for flexible ureteroscopy and SWL: infundibulo-pyelic angle, length, and caliber of the caliceal infundibulum (Figs 5.5–5.8).

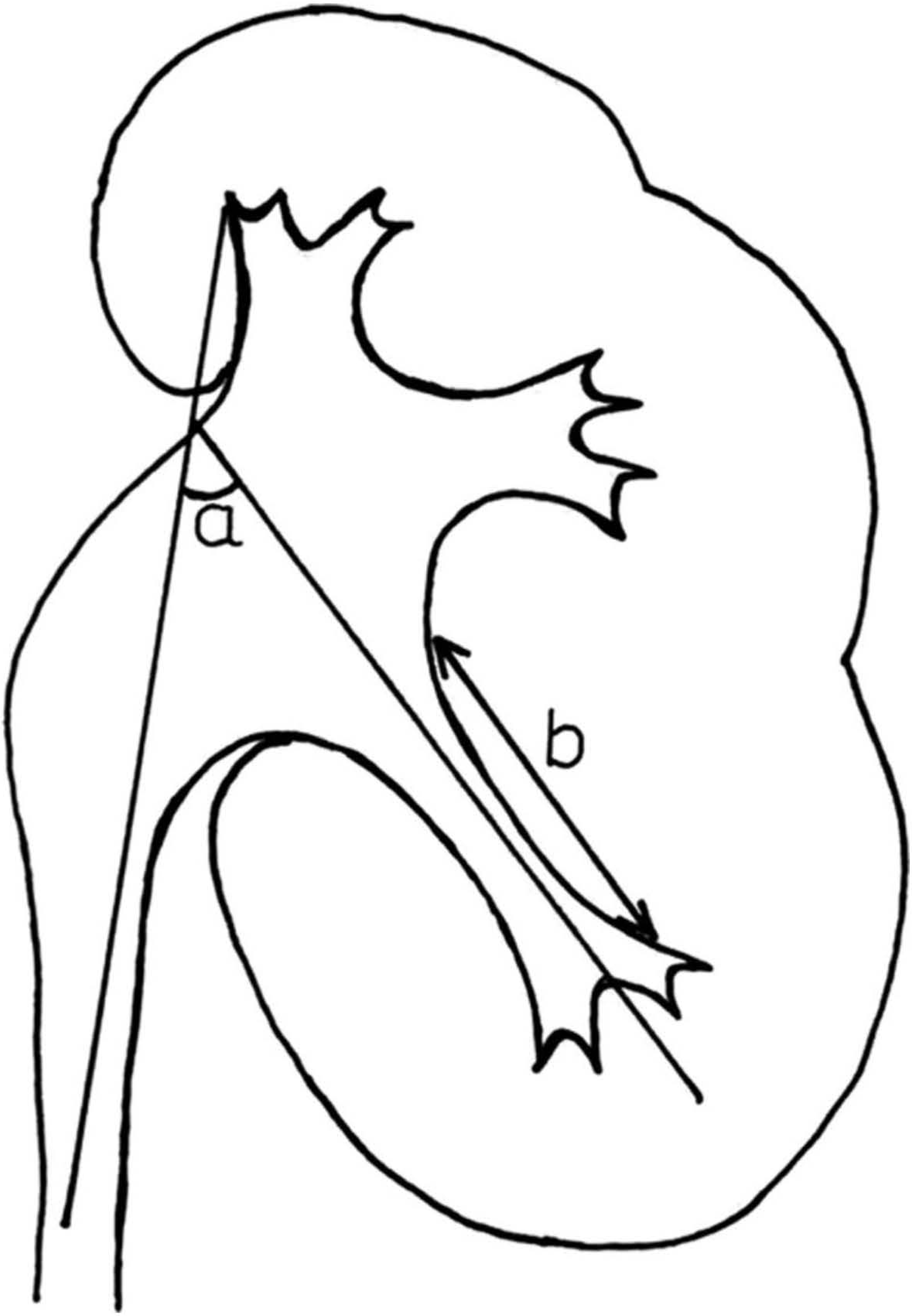

Figure 5.5 Infundibulo-pyelic angle (a) and the length of the lower caliceal infundibulum (b).

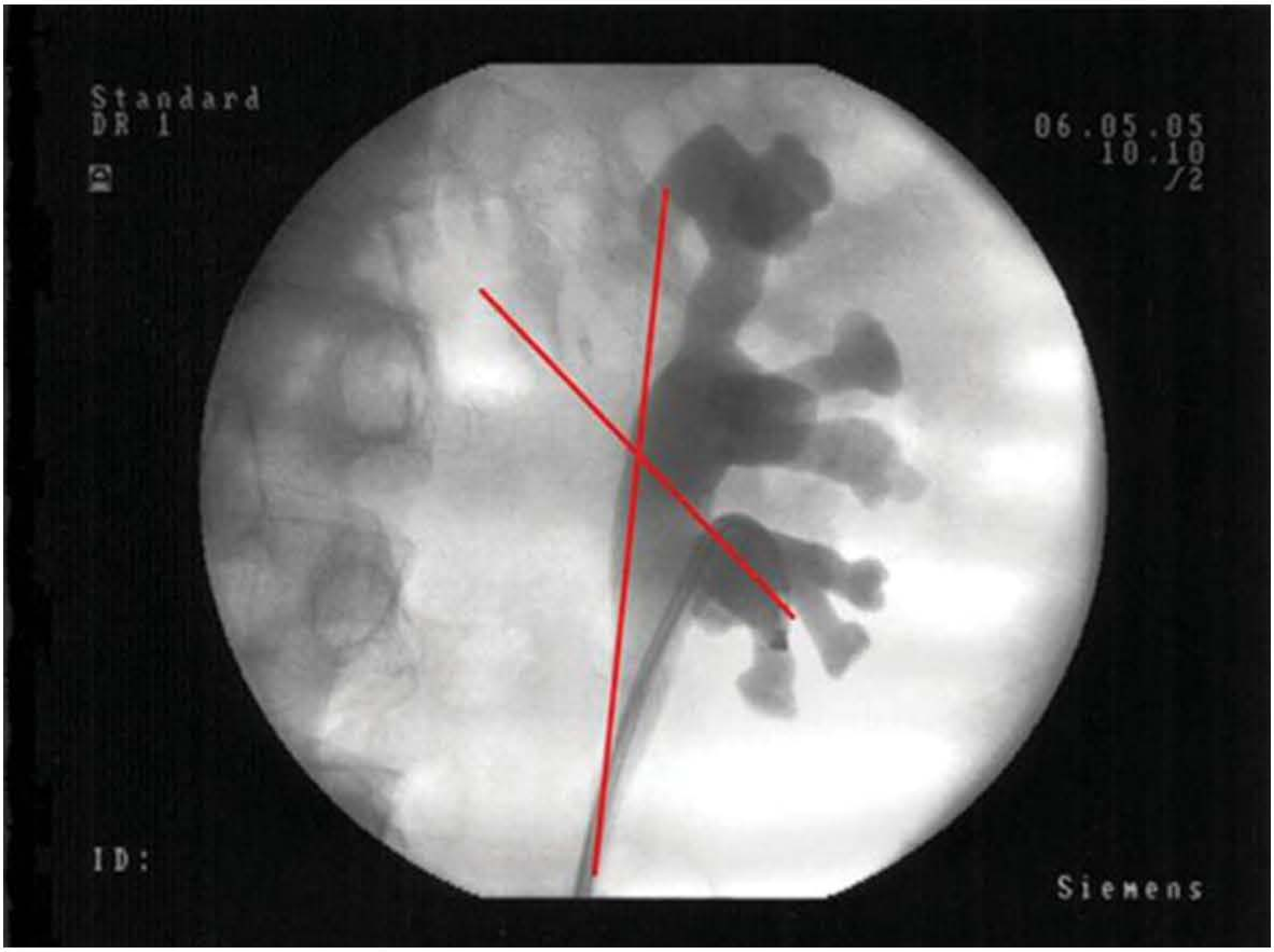
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Figure 5.6 50° Infundibulo-pyelic angle: flexible ureteroscopic approach of the lower calyx using primary active deflection.

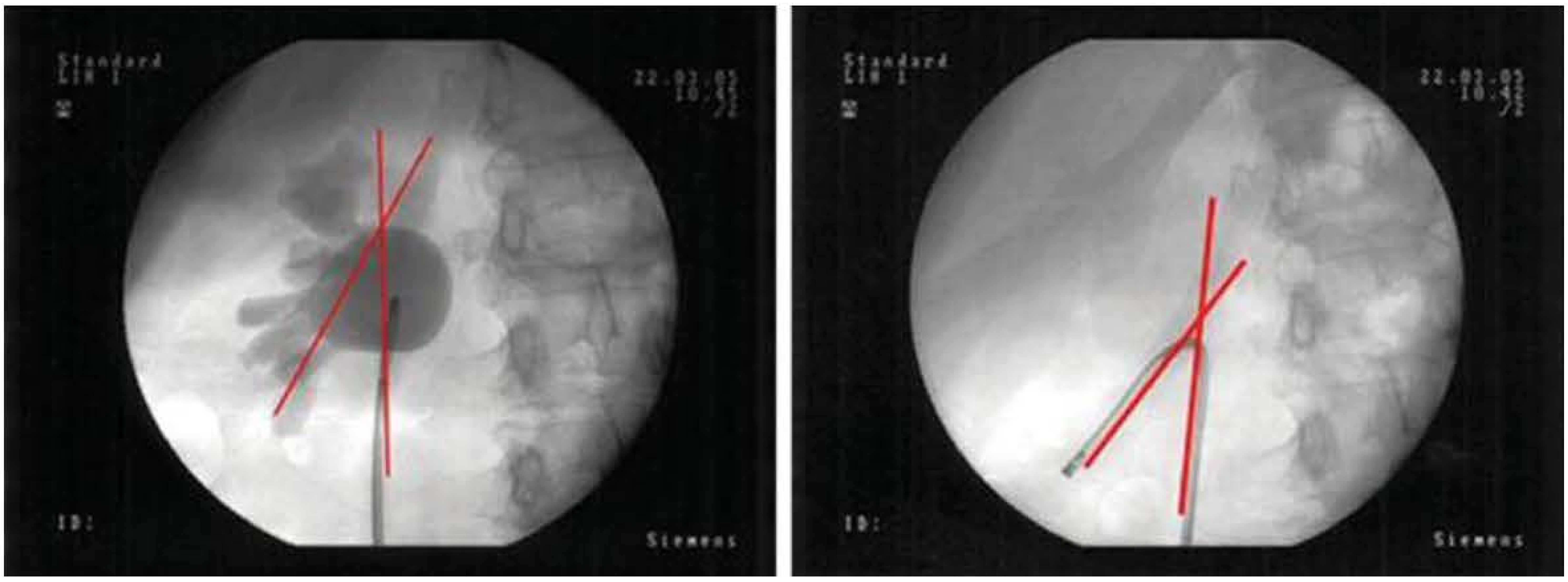
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Figure 5.7 32° Infundibulo-pyelic angle: flexible ureteroscopic approach of the lower calyx using secondary passive deflection.

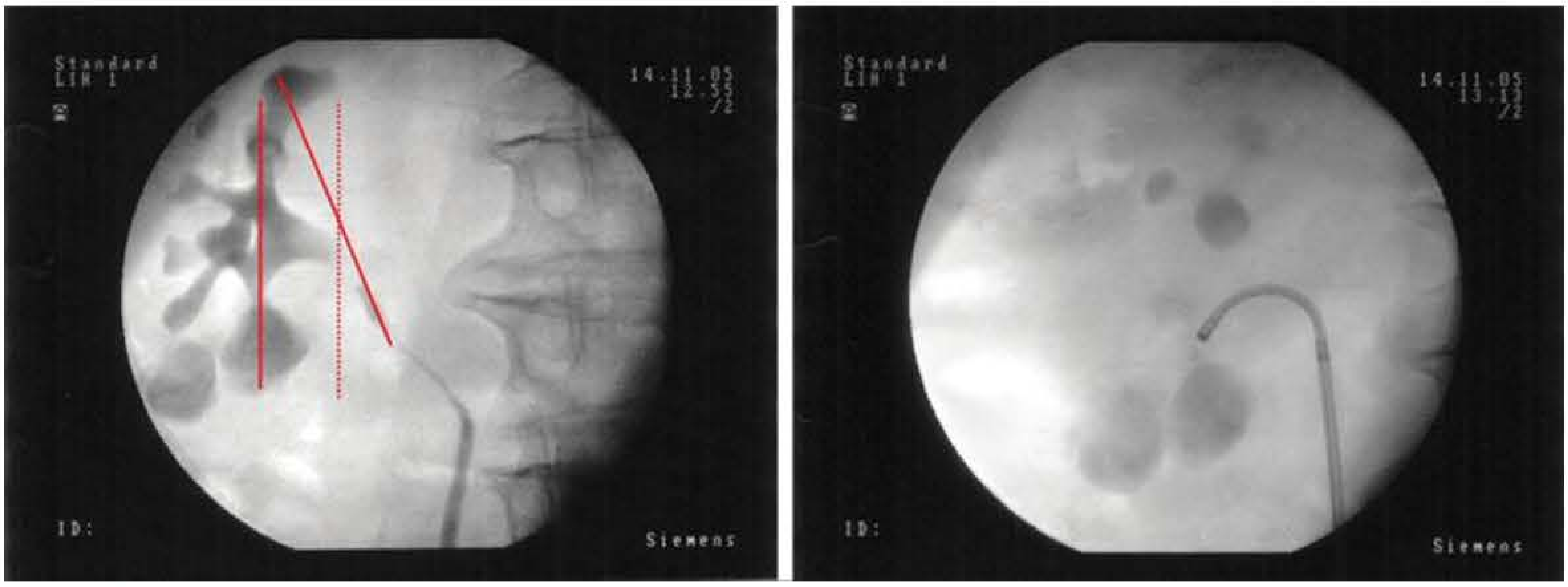

Figure 5.8 **24° Infundibulo-pyelic angle: difficult flexible ureteroscopic approach of the lower calyx.**

In a study conducted by Elbahnasy and coworkers, an infundibulo-pyelic angle of under 90° and a lower caliceal infundibulum with a length greater than 3 cm and a caliber smaller than 5 mm can reduce the performance of flexible ureteroscopy, when simultaneously present.

However, the negative impact of these parameters on the success rate of the retrograde approach is significantly lower than on the elimination of lithiasic fragments after extracorporeal lithiasis (Elbahnasy et al., 1998).

In a study conducted by Grasso and Ficazzola, of the three anatomical features, only the length and caliber of the lower caliceal infundibulum showed a statistically significant correlation with the success rate of retrograde flexible ureteroscopy (Grasso and Ficazzola, 1999).

The presence of pathological changes in the pyelocaliceal system may also negatively affect the performances of the method. Thus, stenoses at various sites may limit flexible ureteroscopic access to the entire upper urinary tract.

Hydronephrosis can have a similar effect, especially when using older models of flexible ureteroscopes with one active and one passive deflection. The latter can be decisive in the approach of the lower caliceal group, but in order to achieve this, the distal part of the ureteroscope must lean on the superior wall of the renal pelvis or at the site of the pyelic implantation of the middle or upper caliceal infundibula (Fig. 5.9). Dilation of the pyelocaliceal system can reduce the amplitude of passive deflection or may even prevent obtaining it, implicitly hindering access to the lower caliceal group. Even in patients without hydronephrosis, during the intervention, due to the irrigation fluid flow (especially if this is done under pressure), a degree of pyelocaliceal dilation may appear that hinders access to the lower pole.

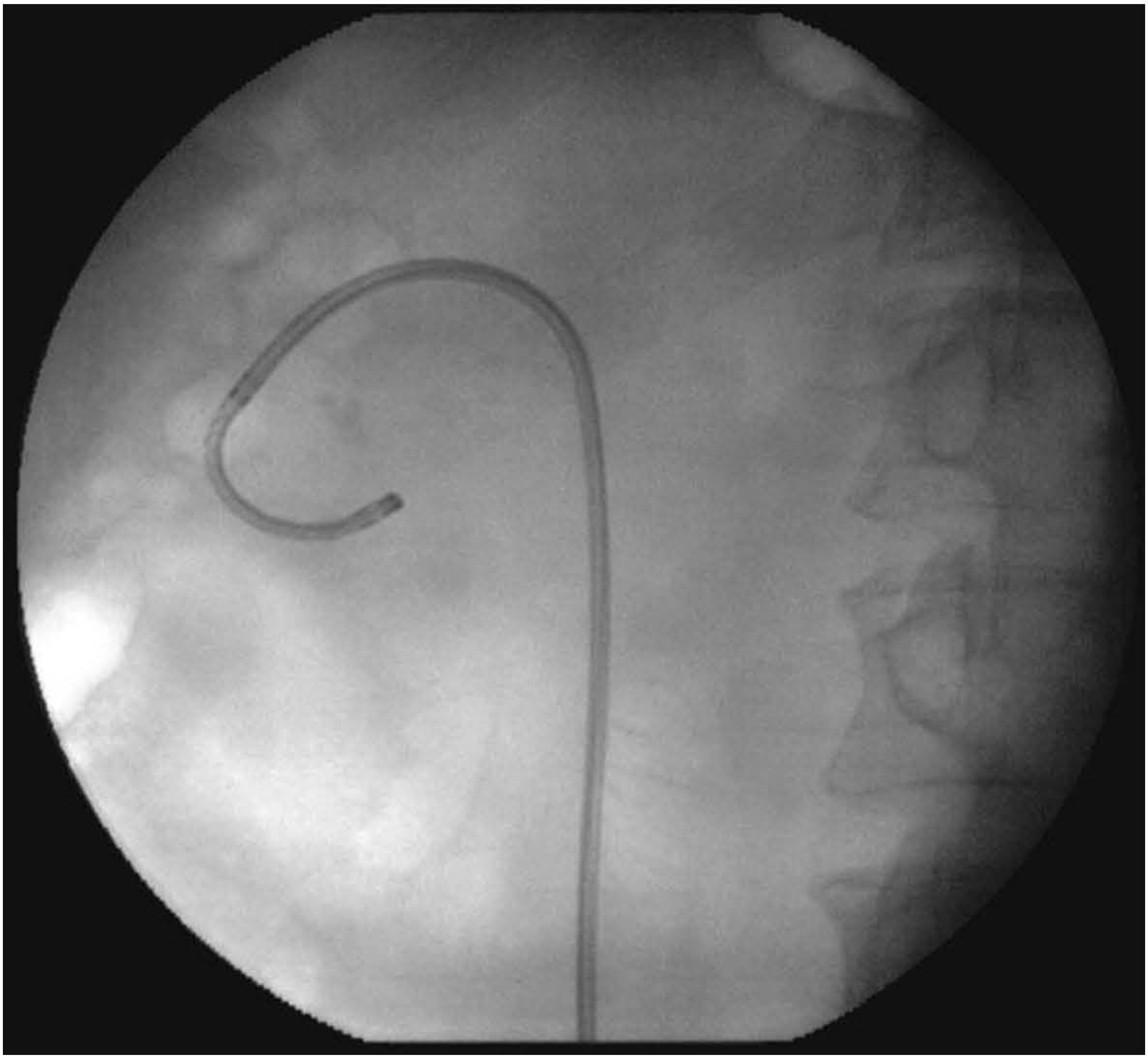

Figure 5.9 **Primary active deflection and secondary passive deflection of the flexible ureteroscope (intraoperative fluoroscopy).**

The insertion of accessory instruments, as well as of fibers or lithotripsy probes into the working channel, has a negative impact on the maximum deflection of the flexible ureteroscope (Fig. 5.10). The influence of these instruments depends on their caliber, on the materials they are made of, and on the type of flexible ureteroscope (Table 5.8).

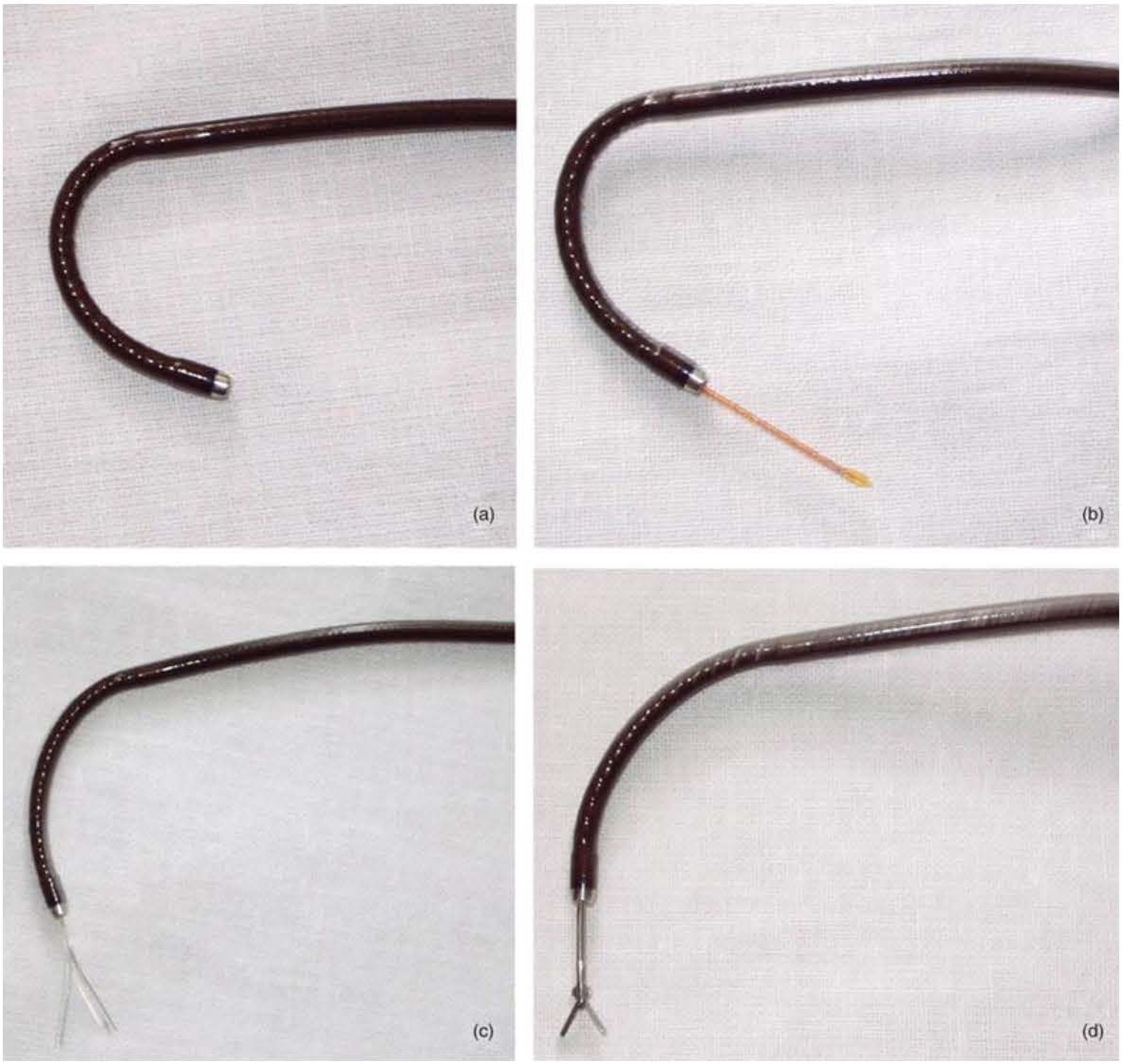

Figure 5.10 **The influence of different instruments inserted into the working channel on the maximum deflection of the flexible ureteroscope.**

Empty working channel (a), 1.6 F electrohydraulic lithotripsy probe (b), tripod forceps (c), extracting forceps (d).

Table 5.8

The Influence of Accessory Instruments Inserted into the Working Channel on the Deflection of Various Models of Flexible Ureteroscopes (Michel et al., 2002; Pasqui et al., 2004)

Model	**ACMI DUR8**	**ACMI DUR8 Elite**	**Olympus URF/ P-3**	**Storz 11274 AA**	**Storz 11278 AU1**	**Wolf 7330.072**	**Wolf 7325.172**
Empty working channel	180°	270°	180°	160°	270°	143°	155°
Ho:YAG 200 µm fiber	156°	228°	155°	120°	260°	140°	142°
Ho:YAG 365 µm fiber	130°	200°	114°	90°	218°	93°	112°
EHL 1.6 F probe	180°	270°	180°	160°	270°	–	155°
EHL 1.9 F probe	179°	246°	154°	133°	265°	–	147°

2.4 F Steel extractor	116°	180°	103°	87°	184°	–	100°
2.4 F Nitinol basket	186°	265°	175°	157°	270°	138°	149°
3 F Nitinol basket	180°	265°	172°	140°	270°	–	149°
3 F Tripod	180°	258°	166°	147°	267°	123°	148°

The lowest negative impact on deflection is observed with electrohydraulic lithotriptor probes, nitinol accessory instruments, and 200 µm laser fibers.

Frustrating intraoperative situations may occur when the lower caliceal stone can be viewed with the flexible ureteroscope having an empty working channel, but becomes impossible to approach after inserting the probes and the lithotriptor fibers, or the accessory instruments.

To solve this issue, a series of technical artifices for moving the stone from the lower calyx have been imagined. These imply, in a first step, approaching the stone and manipulating it with instruments that have a lower influence on the amplitude of the maximum deflection of the flexible ureteroscope. Lithotripsy of the calculi and removal of the fragments by using more robust and efficient tools, but with a significant negative impact on deflection, will be performed in areas of the pyelocaliceal system where the approach no longer requires significant angulation of the flexible ureteroscope.

Another technical artifice is to disassemble the basket catheter, with the removal of the external coating (Fig. 5.11) (Geavlete P, 2005). Landman and Monga, assessing 2.2, 2.4, 3, and 3.2 F basket catheters inserted on the flexible ureteroscope, showed a 15–20° increase of the maximum deflection and a 2- to 30-fold increase in the irrigation flow after removing their external layer (Landman et al., 2002).

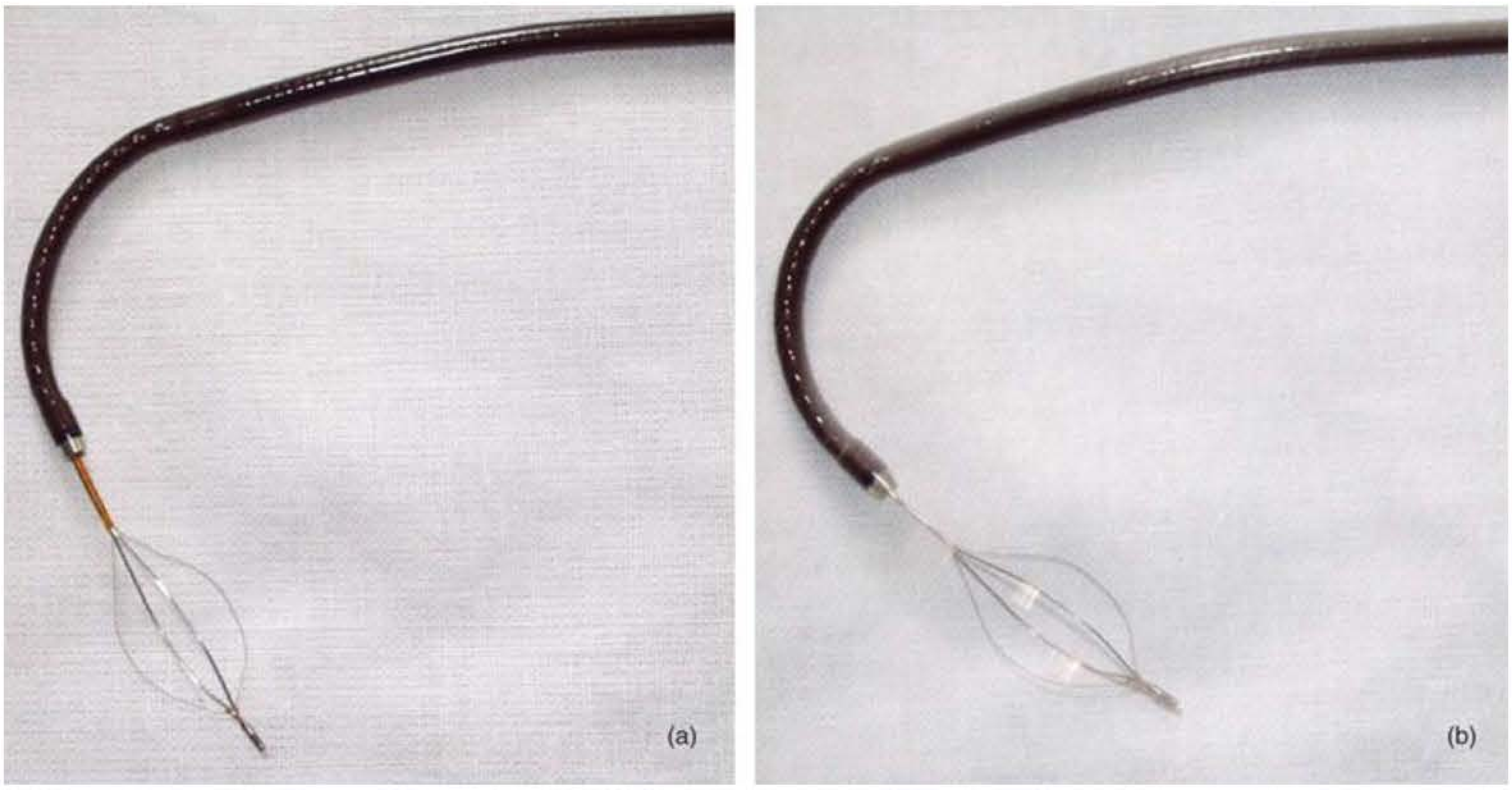

Figure 5.11 **The difference regarding the maximum deflection of the flexible ureteroscope between inserting the basket catheter with (a) or without the external sheath (b) into the working channel.**

Nitinol instruments have a superior flexibility compared to their steel counterparts and therefore a lower negative impact on deflection.

The new generation of flexible ureteroscopes, with two active deflections or a single high-amplitude active deflection, have a superior maneuverability at the pyelocaliceal level and are less influenced by the previously described factors (Pasqui et al., 2004).

Chiu and coworkers analyzed the differences between new-generation flexible ureteroscope models (ACMI DUR-8 Elite and Storz 11278AU1) and their predecessors (ACMI DUR-8 and Storz 11274AAU). Although the insertion of accessory instruments into the working channel influenced all four ureteroscopes, the impact on the maximum amplitude of deflection was greater in the older models. Thus, for ACMI DUR-8 Elite and Storz 11278AU1, 0.7 and respectively 2.8% reductions were registered, compared to 9.6 and 5% in the older models (Chiu et al., 2004).

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6.1. Generalities

Ureteral calculi were first mentioned by Ambroise Pare in 1564. He also described impaction of stones in both ureters as a cause of death (Murphy, 1972). Although ureteral calculi were subsequently mentioned by many authors, a successful intervention for extracting them was performed only after 200 years. In 1788, Desault designed an instrument used for incising the ureter and extracting the stone. In 1879, Thomas Emmet performed two interventions for the first time. In one case, he used a forceps to extract a stone from the ureteral orifice, while in another case he performed a transvaginal ureterolithotomy. Many types of approaches were used in the following period of time: transperitoneal, perineal, sacral, and vaginal. Different types of incisions were described according to the location of the lithiasis: Pfannenstiel- or Gibson-type incisions for distal ureteral calculi and subcostal incision for proximal ones. Many attempts were made to blindly extract calculi before cystoscopy was developed. The first manipulation of a ureteral stone was achieved by Gustav Kolisher. He located the stone situated several centimeters above the ureteral orifice using a catheter with a metallic end, through which he injected 30 cc of sterile oil (Murphy, 1972). The discovery of X-rays in 1895, together with the introduction of cystoscopy, paved the way for the use of endoscopic instruments for manipulating calculi (Silber and Smith, 1986).

6.2. Indications

The purpose of the surgical treatment of upper urinary tract lithiasis is to completely extract the stone with minimal morbidity. Technological advances have essentially changed the treatment of this condition. Until the 1980s, open surgical ureterolithotomy and extraction of the stones with a basket catheter under fluoroscopic control were the only alternatives for their treatment. The development of minimally invasive therapeutic alternatives for urinary lithiasis is closely linked to the technological evolution in different fields including: optical fibers, imagistics, shock wave lithotripsy (SWL), and ultrasonic, electrohydraulic, or laser lithotripters. As a result of these advances, modern techniques for treating calculi were developed, including ureteroscopic extraction, percutaneous nephrolithotomy, and SWL. These led to the development of the therapeutic arsenal for ureteral calculi, regardless of their size or location. The term of endourology was broadened, including antegrade and retrograde techniques for urinary tract approach.

Extracorporeal lithotripsy, introduced into urological practice in 1982 by Chaussy, is currently one of the elective methods of treatment for upper urinary tract calculi (Chaussy et al., 1982).

Theoretically, SWL is less invasive, the anesthetic requirement being limited, while instrumentation of patients is only necessary in a small number of cases. However, it is encumbered by a high rate of retreatment, requiring auxiliary procedures, which imply an additional morbidity.

The quite low success rate, as well as the problems that may occur when using this method, together with the advances regarding ureteroscopy, have recently made the latter become a first-line therapy for ureteral calculi, regardless of their location.

With the reduction of the caliber of semirigid ureteroscopes, the development of laser technology, and the introduction of increasingly better and reliable flexible ureteroscopes, the indications for ureteroscopic lithotripsy have broadened, including the approach of pyelocaliceal lithiasis.

Several authors currently consider that extracorporeal lithotripsy is reserved only for radiopaque reno-ureteral lithiasis, with a reduced hardness, nonimpacted, while retrograde ureteroscopy can be used for any type of stones. The major advantage of retrograde ureteroscopy compared to other techniques of intracorporeal lithotripsy is represented by the use of a natural pathway of approach.

In 2007, AUA and EAU reached a consensus regarding the therapeutic indications for ureteral lithiasis, individualized for the index patient and for those presenting a series of particularities. The guideline defines the index patient as follows: an adult person (with the exception of pregnant women) with noncystine/nonuric ureteral lithiasis, without kidney stones, with normal contralateral renal function, and with a medical and anatomical condition that allow any one of the treatment options to be undertaken.

For this type of patient, in the presence of ureteral calculi <10 mm and with an optimal control of symptoms, the first therapeutic option is represented by pharmacological therapy favoring spontaneous passage. Measures for the active removal of the calculi are recommended when the obstruction persists, when the stone does not progress, or when the patient presents persistent colicative pain that cannot be controlled by therapy. For calculi >10 mm, both SWL and ureteroscopy represent first-line therapeutical alternatives.

The increased hardness of cystine stones and, implicitly, the reduced success rates of SWL in these patients require retrograde ureteroscopy with intracorporeal lithotripsy (Ho:YAG, ultrasonic, or pneumatic) as the first therapeutic alternative. In patients with uric lithiasis, chemolysis associated with pharmacological expulsive therapy is a viable option. Ureteroscopy is a very efficient method for treating patients with this type of lithiasis, who are not candidates for pharmacological therapy (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

For septic patients with lithiasic ureteral obstruction, emergency decompression of the urinary tract will be performed (percutaneous nephrostomy and JJ catheter stenting), and the definitive treatment will be performed after reequilibration.

Semirigid or flexible ureteroscopic approach is preferred to SWL in patients who require complete extraction of the stones: pilots, personnel on long-distance ships, female patients who wish to become pregnant in the near future, and patients who are going to travel to countries with a less developed medical infrastucture (Kumon et al., 2007). Last but not least, the choice of a therapeutic alternative depends on the technical endowment of the urological department, as well as on the patient's option.

6.2.1. Indications of Ureteroscopy in the Treatment of Ureteral Lithiasis

The essential element in the management of ureteral calculi is represented by the choice of the optimal therapeutic alternative.

Although the initial experience concerning rigid ureteroscopy led to favorable results regarding distal ureteral lithiasis, the success rate for middle and proximal ureteral calculi was low. The miniaturization of rigid ureteroscopes, the introduction of semirigid ureteroscopes and subsequently of flexible ones, and the use of better lithotripters improved the retrograde endoscopic approach of proximal calculi (Erhard et al., 1996).

As opposed to rigid or semirigid ureteroscopy, the flexible one has limited indications for the approach of pelvic ureteral calculi, due to the difficulties in maneuvering at this level, this method proving its efficiency especially in the treatment of iliac or lumbar ureteral calculi (Tawfiek and Bagley, 1999; Lam et al., 2002).

However, flexible ureteroscopy should be seen as a method that is complementary to the rigid or semirigid one for ureteral lithiasis. It can prove to be essential in certain circumstances, when semirigid retrograde approach is inefficient, impossible, or contraindicated: patients with urinary derivations (Figs 6.1–6.3), important ureteral sinuosities, large prostatic adenomas, etc.

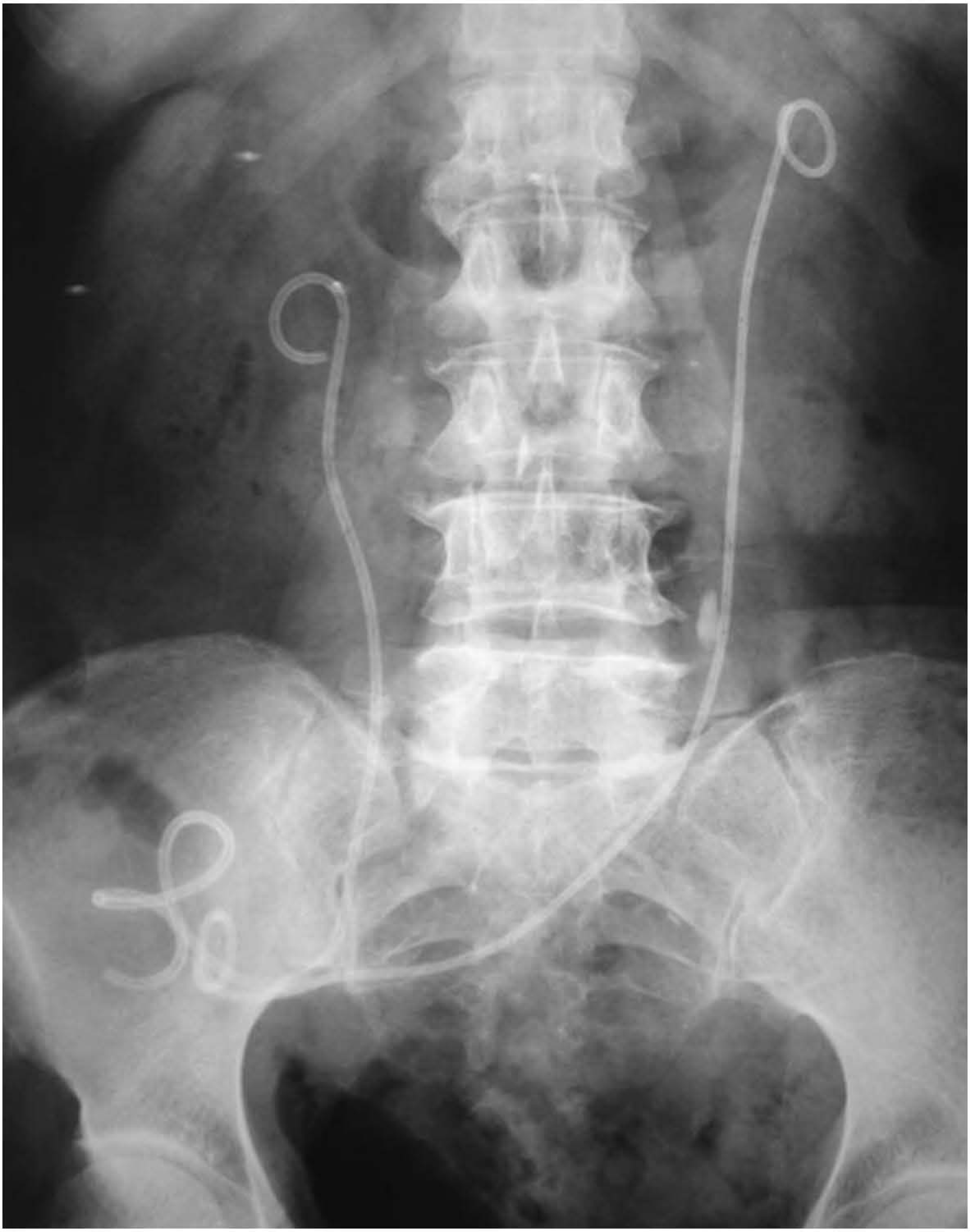


Figure 6.1 Left ureteral stone in a patient with ileal reservoir-type urinary derivation.

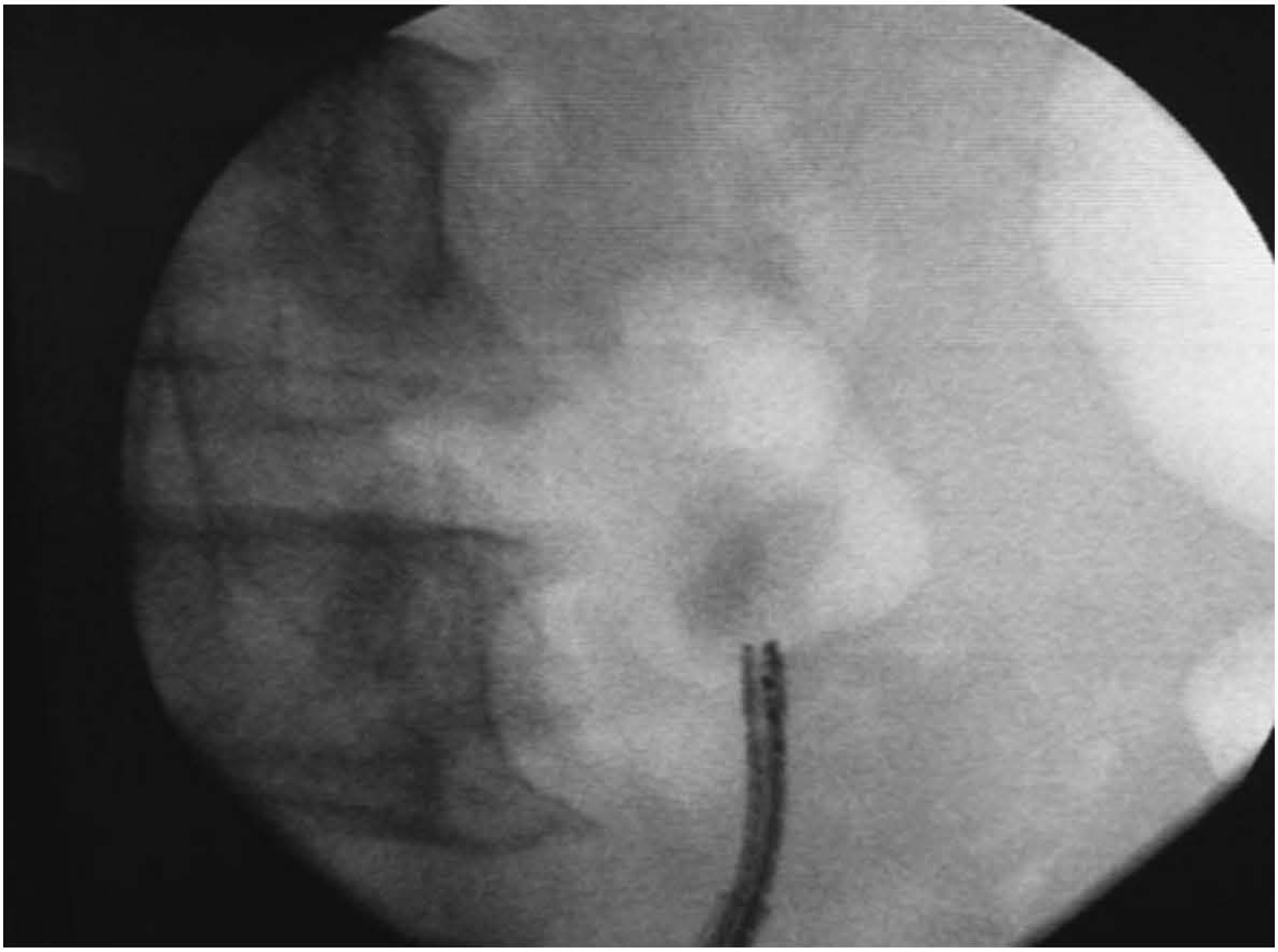


Figure 6.2 Flexible ureteroscopic approach of the ureteral stone.

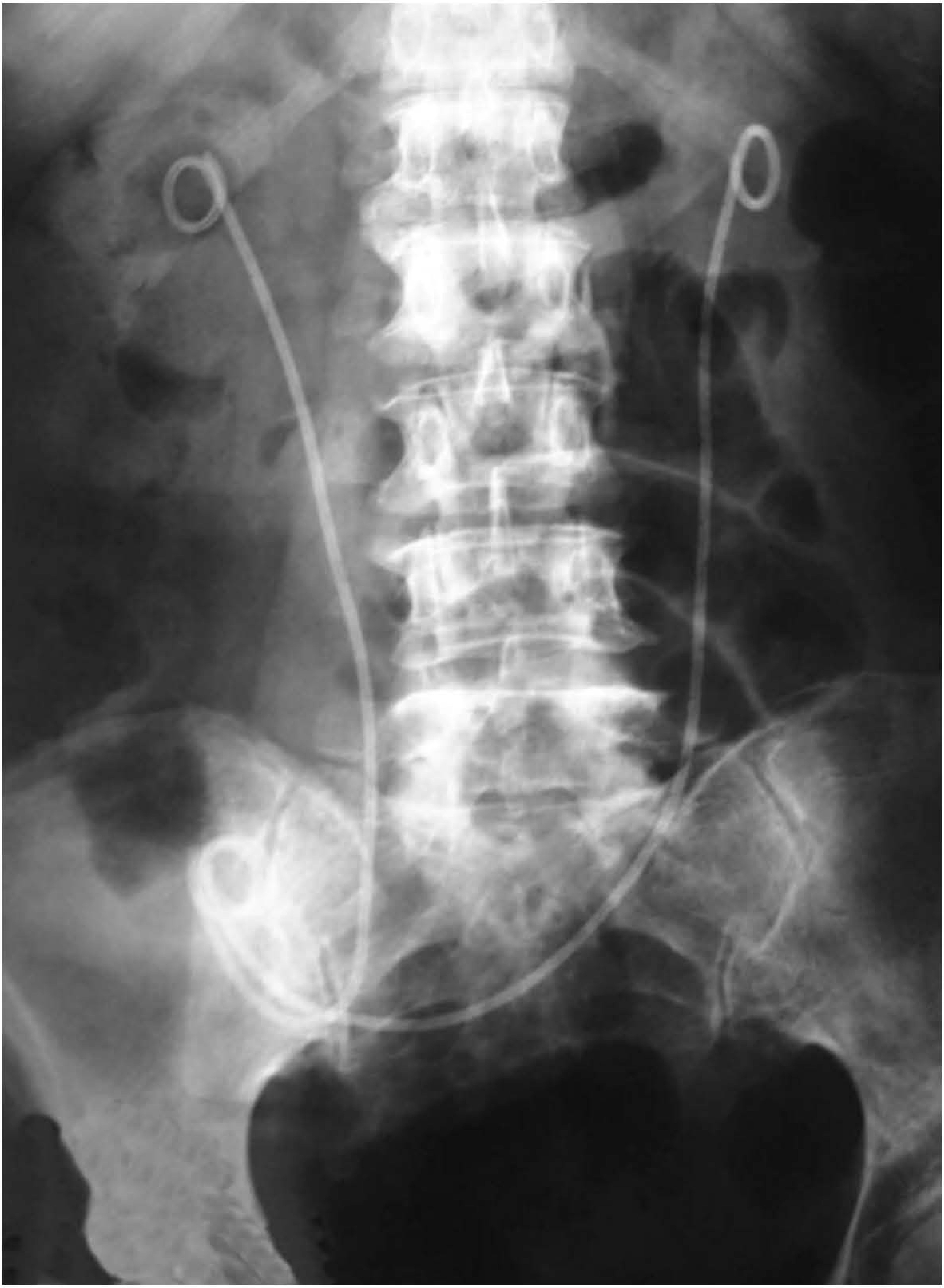


Figure 6.3 **Stone-free aspect at the end of the intervention.**

6.2.2. Indications of Ureteroscopy in the Treatment of Pyelocaliceal Lithiasis

The modern therapeutic options for pyelocaliceal calculi are represented by SWL, flexible ureteroscopy, and percutaneous nephrolithotomy, the therapeutic strategy being individualized according to the particularities of each case.

SWL is the elective method in the treatment of pyelocaliceal lithiasis with sizes of less than 20 mm. However, for calculi with certain chemical compositions (cystine, calcium oxalate monohydrate, etc.), extracorporeal lithotripsy has a modest success rate (Busby and Low, 2004).

Flexible ureteroscopy is indicated in patients with SWL-resistant lithiasis, especially with sizes of less than 2 cm, those with large calculi benefiting from the percutaneous approach.

Also, SWL has a modest success rate in patients with lower caliceal lithiasis, due to the difficult evacuation of the lithiasic fragments. In these cases, flexible retrograde approach may be the first therapeutic alternative (Busby and Low, 2004).

Patients with renal lithiasis and skeletal anomalies, morbid obesity, hemorrhagic diathesis, and kidney malformations, in whom percutaneous approach and/or SWL are contraindicated or very difficult to perform, are also candidates for flexible retrograde ureteroscopic approach (Busby and Low, 2004).

This method can also be an alternative in the treatment of intradiverticular lithiasis (Monga and Beeman, 2004).

6.3. Rigid and semirigid retrograde ureteroscopy technique

Semirigid ureteroscopes are currently used more and more frequently, being less traumatic than the rigid ones and better than the flexible ones (Harmon et al., 1996). Their external diameter is approximately equal to that of rigid ureteroscopes, but the endoscopic field remains round all the time, even if the instrument is flexed more than 4 cm, due to the fact that the light is transmitted through optical fibers similar to those used in the case of flexible ureterorenoscopes.

Rigid or semirigid ureteroscopy also presents a series of other important advantages compared to the use of the flexible instrument. Thus, the durability and reduced costs represent arguments in its favor. Also, the caliber of the working channel of the ureteroscopes allows the use of a large variety of auxiliary instruments, ensuring a better irrigation and visibility.

These advantages are counterbalanced by the difficulties in approaching the proximal ureter (especially in men) and the pyelocaliceal system, as well as by the high risk of intraoperative incidents and complications.

6.3.1. Preliminary Measures

The preliminary measures have in mind patient selection, preoperative preparation, anesthesia, the steps preceding the actual intervention, and patient positioning on the operating table.

6.3.1.1. Patient Selection

Prior anamnestic assessment may provide important data regarding associated diseases, as well as any previous interventions that may make the ureteroscopic approach more difficult.

The preoperative clinical and paraclinical examinations are essential for preparing and planning the endoscopic intervention. Retrograde ureteroscopy is difficult in patients in whom the standard lithotomy position cannot be ensured due to skeletal deformations. The presence of a prostatic median lobe or a large cystocel may also determine difficulties in achieving a rigid or semirigid retrograde ureteroscopic approach.

Preoperative imaging explorations include ultrasonography of the urinary tract, simple renovesical radiography, and intravenous urography.

Preoperative intravenous urography or retrograde ureteropyelography allow for the specification of the position and size of the stone, the degree of obstructive suffering of the affected renal unit, and the anatomy of the urinary tract below and above the stone, as well as some congenital (ureteral bifidities or duplicities) or acquired conditions (ureteral stenoses or retroperitoneal fibrosis) that may make the retrograde endoscopic approach more difficult. This information is useful in estimating the intervention’s degree of difficulty, guiding the planning of the procedural tactics and its associated risks.

The urine must be sterile. Preoperative urinary infection requires adequate treatment. In case of a positive uroculture, targeted antibiotic therapy should precede the intervention by 48–72 h. Acute pyelonephritis contraindicates retrograde ureteroscopy. In this situation, ureteroscopy will be preceded by the clinical resolution of the septic status by ensuring the drainage of the renal unit by percutaneous nephrostomy or ureteral stenting and antibiotic treatment according to the antibiogram.

Even in the absence of a urinary infection, parenteral antibiotic prophylaxis is indicated immediately preoperatively or 12 h before the intervention.

Assessment of coagulation plays an essential role, not only in choosing the therapeutic modality and the instruments, but also in anticipating an increased risk of intraoperative bleeding, with a consecutive reduction of visibility. Oral anticoagulation treatment must be replaced before the intervention with administration of low molecular weight heparin, with predictable and easier to correct effects.

6.3.1.2. Patient Positioning

The patient should be placed on the endoscopy table in the standard lithotomy position, with the lower limb contralateral to the approached ureter in hyperabduction and in a lower position (Fig. 6.4).

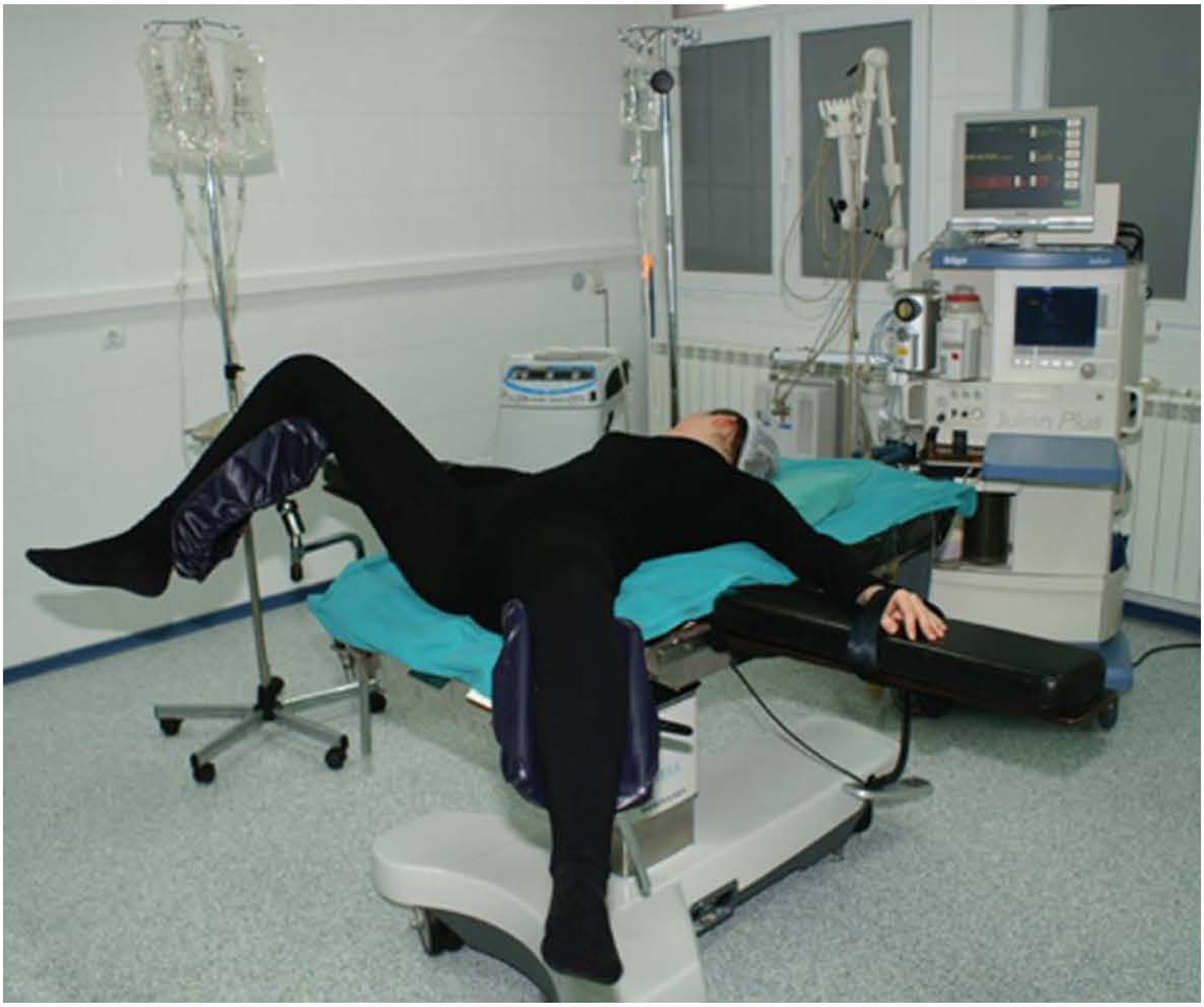


Figure 6.4 **Standard lithotomy position for the retrograde approach of the right ureter.**

This position allows the ureteroscope to be guided in the direction of the intramural trajectory of the ureter, while the movements of the surgeon are not limited by the contralateral lower limb. Sometimes, the intervention can be performed in better conditions if the surgeon places himself outside this lower limb.

Some authors prefer lowering the ipsilateral lower limb, the ureteroscopic approach being facilitated by raising the respective hemitrigone, with the modification of the position of the ureteral orifice in a straight line and horizontal in relation with the bladder neck.

6.3.1.3. The Endourologic Equipment

Performing any endoscopic procedure requires preparing an adequate working table containing frequently used instruments and equipment.

Thus, the following are necessary: cystoscope, rigid, semirigid, or flexible ureteroscopes of different sizes and adequate auxiliary instruments, different guidewires (with curved or straight soft end, hydrophilic guidewire), ureteral catheters, stents, ureteral dilators, basket catheters, and energy generators (ultrasonic, electrohydraulic, pneumatic, or laser). The presence of these instruments determines a reduction of delays, of the operating time, and of the anesthetic risk.

6.3.1.4. Anesthesia

The type of anesthesia used for the treatment of ureteral lithiasis depends both on the technological level and on the type of available anesthetic technique. Both have evolved considerably over the last few years. Before the introduction of extracorporeal lithotripsy and of ureteroscopy, surgical ureterolithotomy required the use of general anesthesia. Ureteroscopy was initially performed exclusively under general or spinal anesthesia due to the high-caliber ureteroscopes that were used and to the necessity of dilating the ureteral orifice (Strohmaier et al., 1999).

The arguments in favor of general anesthesia are represented by the control of breathing, avoiding the patient's movement, or coughing, which may produce lesions of the upper urinary tract. However, a review of the data in the literature did not show significant differences regarding the incidence of iatrogenic lesions during retrograde ureteroscopy with or without general anesthesia.

There are situations in which general anesthesia cannot be induced due to cardiovascular or respiratory conditions. In these cases, regional blockade should also include the fibers of the sympathetic nerves at the T8 level that transmit pain.

The use of regional anesthesia has seen a decline due to the period of time necessary for inducing anesthesia and the increased recovery period in the postoperative unit. The quicker induction of spinal anesthesia compared to the epidural one, together with the localized blockade, are arguments in favor of its use. Also, this type of anesthesia is indicated in pregnant women due to the reduced transfer of drugs toward the fetus. However, in patients with severe cardiovascular diseases, epidural anesthesia is preferred. In these situations, the degree and extent of the anesthetic blockade are easier to control.

Over the last years, the intent of reducing the operating time and the convalescence period, without however giving up on intraoperative comfort, have determined a diversification of the indications of local anesthesia with or without analgosedation. The reduced duration of action of sedoanalgesic agents allows their easy titration and quick postprocedural recovery (Rittenburg et al., 1987; Abdel-Razzak and Bagley, 1992; 1993). Even the treatment of renal or ureteral lithiasis can be performed under this type of anesthesia, if the intervention is not very complex and requires a limited period of time (Abdel-Razzak and Bagley, 1992; Park et al., 2004). A duration of 60–90 min is considered the limit over which regional or general anesthesia is required (Cybulski et al., 2004). Also, overdistension of the upper urinary tract with irrigation fluid should be avoided because it may cause lumbar pains.

Starting the intervention under local anesthesia does not prevent the induction of general anesthesia at any moment, if the operating time is prolonged or if this is required by the patient's condition. Local anesthesia of the urethra with 2% lidocaine gel may be sufficient for performing retrograde ureteroscopy in certain situations. However, in most cases, for ensuring the patient's comfort, sedation by intravenous injection of diazepam, midazolam, or narcotics (fentanyl, morphine, demerol) is required (Cybulski et al., 2004).

The introduction into medical practice of quickly acting substances for intravenous sedation or analgesia, together with the reduction of ureteroscope calibers, have led to an increased success of ureteroscopy performed under local anesthesia associated with sedoanalgesia.

The safety and tolerability of this intervention have been confirmed by numerous studies. Some authors state that approximately half of the ureteroscopic procedures performed in a urology department can be carried out under local anesthesia associated with sedation (Cybulski et al., 2004). However, the studies that were performed included especially women with distal ureteral calculi. The dilation of the ureteral orifice does not represent a contraindication for local anesthesia with intravenous sedation. In men, the discomfort determined by rigid ureteroscopy is produced by the passing of the instruments through the membranous urethra and bladder neck.

6.3.1.5. Irrigation

Irrigation ensures the visibility necessary for the ureteroscopic procedures. The most frequently used irrigation fluid is saline solution heated to body temperature, especially due to the risk of absorption through pyelolymphatic or pyelovenous reflux, or after ureteral perforation (Bagley et al., 1985). If electroresection is necessary, saline solution can be replaced by glycine solution, sterile water, or sorbitol.

Ideally, the intrarenal pressure should be maintained under 30 cm H_2O. Overdistension of the collecting system may largely be responsible for the induction of postoperative pain (Bagley DH, 1988). The pressure may be ensured by suspending the saline solution bags 30–50 cm above the patient's plane (Fig. 6.5).

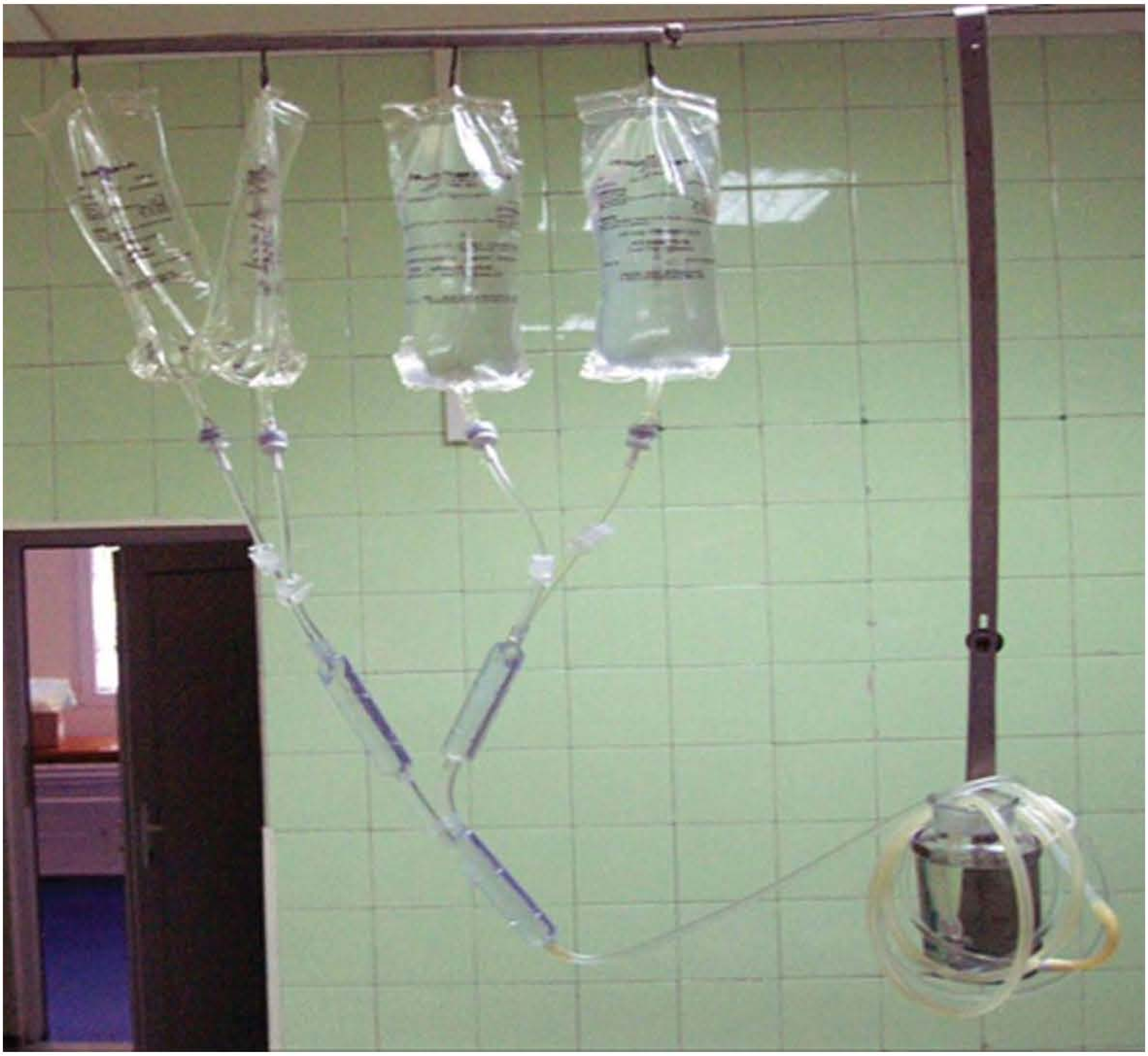


Figure 6.5 **Device for suspending the irrigation fluid bags.**

Due to the resistance of the tubing and of the irrigation channel, the pressure generated by gravity may not provide an adequate visibility. For this reason, different systems that determine optimization of visibility through an accurate control of pressure have been described, without the distension of the renal collecting system (Fig. 6.6). The advantages of these techniques consist of the possibility of increasing pressure during the critical moments of the intervention. The disadvantages include the lack of control of constant visualization and the necessity for an operator to maneuver the equipment in complex cases.

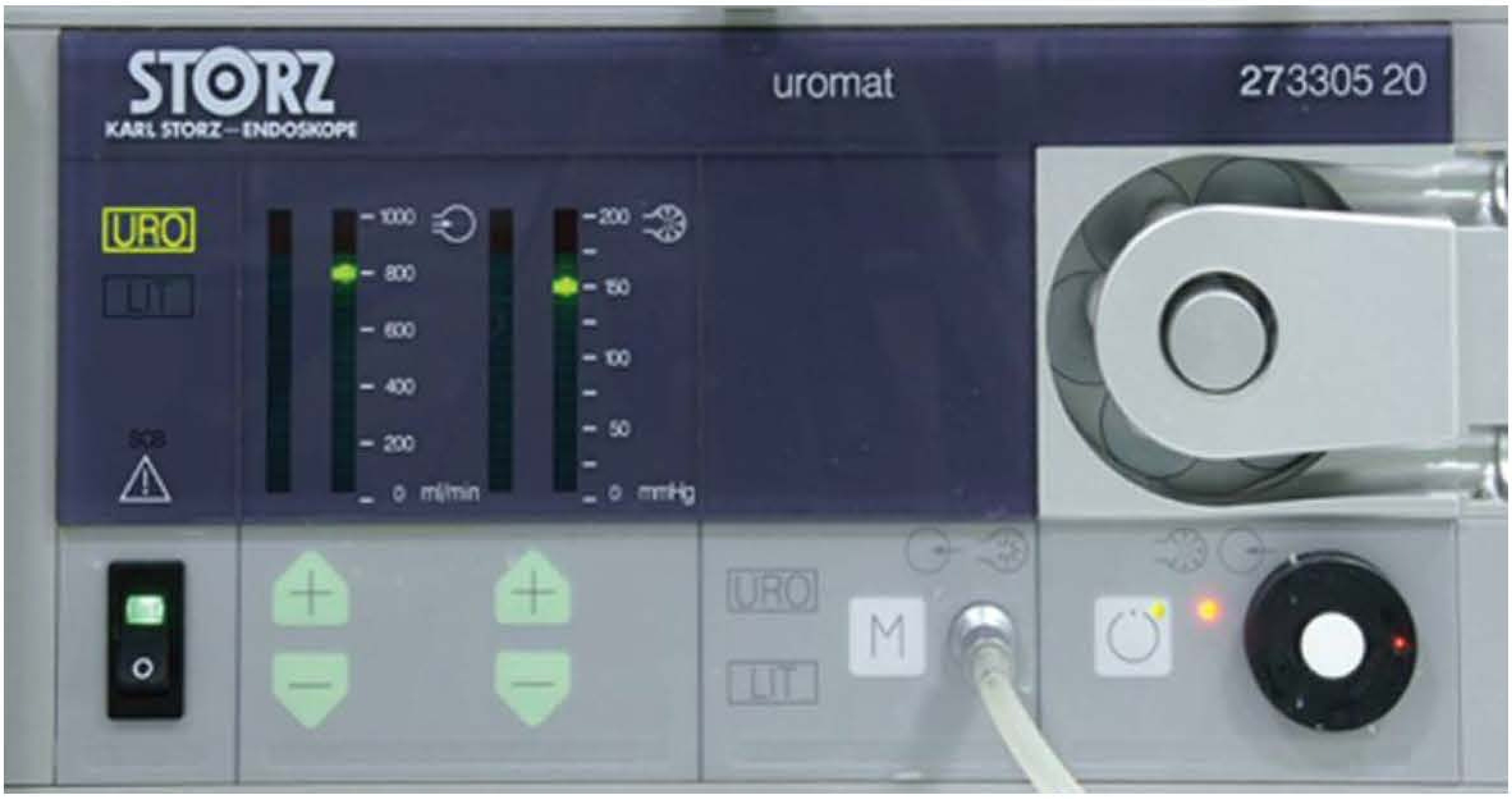


Figure 6.6 **The Uromat device for controlling the irrigation pressure.**

The systems for pressure control are also useful for countering the negative effects on the irrigation flow of the accessory instruments introduced through the working channel that determines a reduction of the standard irrigation (Wilson et al., 1990; Parkin et al., 2002).

In conclusion, the operator should use a level of pressure that ensures an adequate visibility, at the same time avoiding the risk of absorption and pyelovenous reflux.

6.3.2. Cystoscopy

Cystoscopy preceding the ureteroscopic approach represents the first step of the intervention, being necessary for assessing the morphology and dimensions of the ureteral orifice (Fig. 6.7) and any associated bladder conditions.

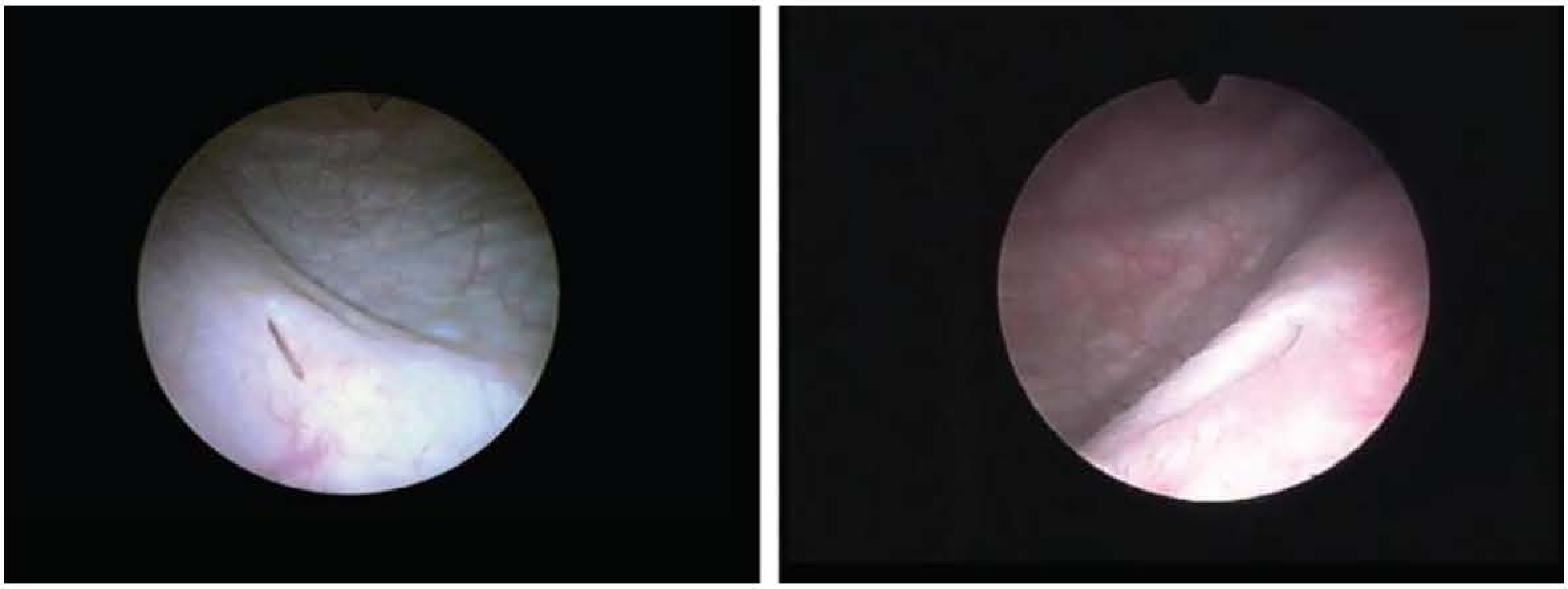


Figure 6.7 **Cystoscopic identification of the ureteral orifices.**

If additional data regarding the upper urinary tract are necessary, an intraoperative retrograde pyelography may be performed (Fig. 6.8).

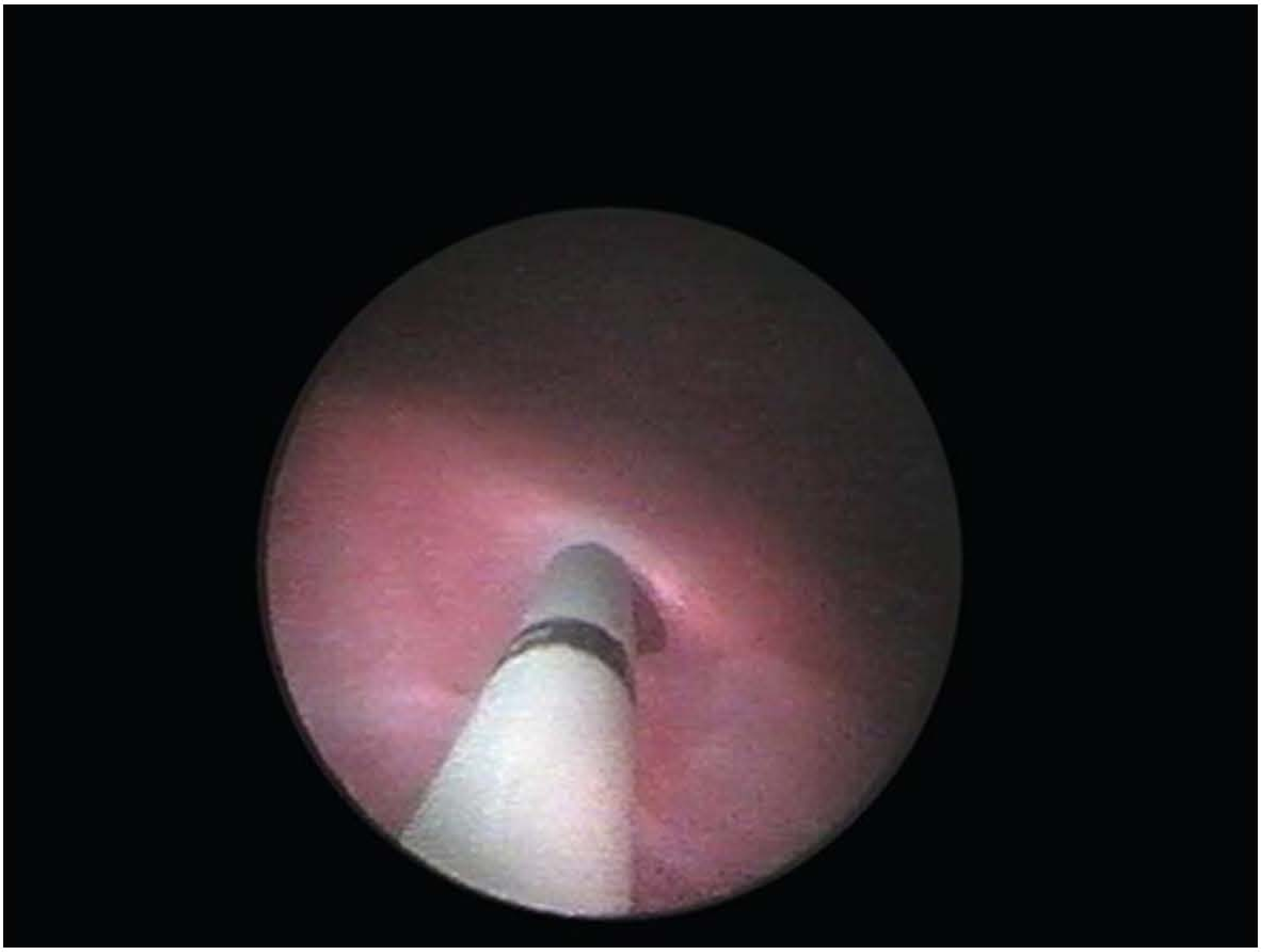


Figure 6.8 **Catheter inserted into the ureteral orifice for performing a retrograde pyelography.**

6.3.3. Placing the Safety Guidewire

After the cystoscopic assessment, a 0.035–0.038 in. guidewire with a soft end is placed up to the renal pelvis (Fig. 6.9).

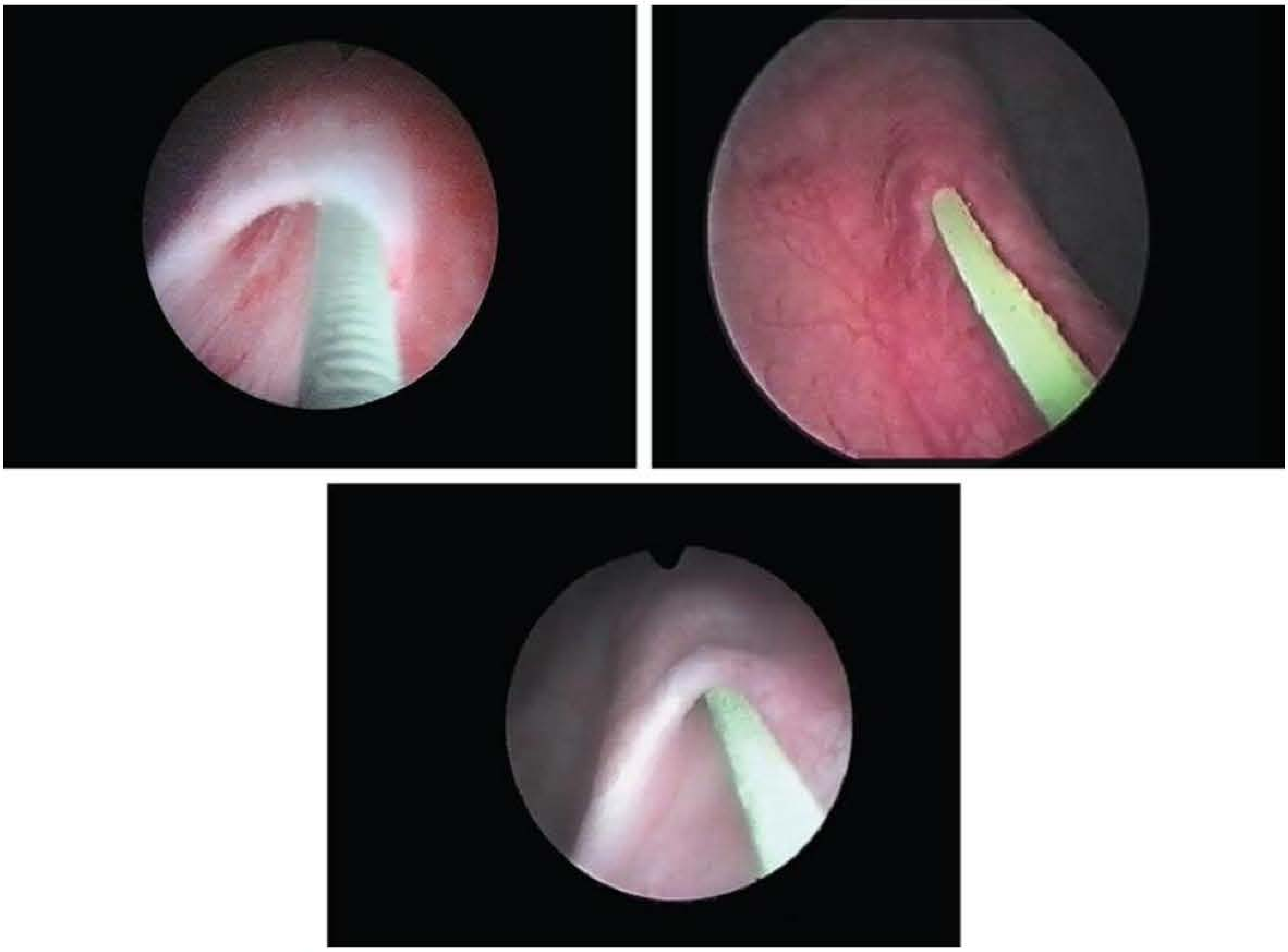


Figure 6.9 **Insertion of the guidewire into the ureteral orifice.**

This safety guidewire plays an essential role in maintaining the access toward the upper urinary tract, allowing repeated passages of the ureteroscope. The guidewire guides the ascension of the endoscope and contributes to the prevention of parietal lesions during ureteral dilation, ureteroscopy, or stent placing. After placing the safety guidewire, some authors recommend pharmacological stimulation of diuresis in order to reduce pyelorenal reflux and infectious complications. The accessibility of different types of guidewires is extremely important, especially in the case of patients in whom ureteroscopic approach may be difficult.

In difficult cases, placing the guidewire may be facilitated by directing it through a ureteral catheter or under direct ureteroscopic control (Fig. 6.10).

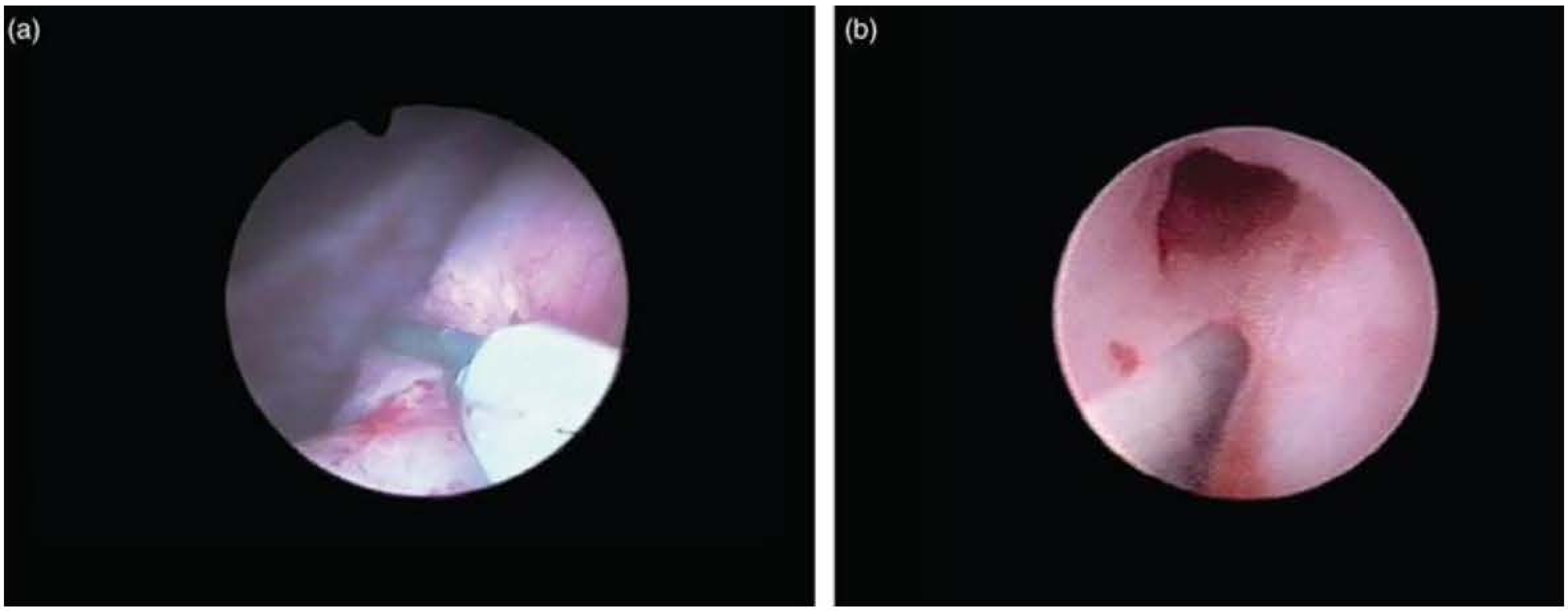


Figure 6.10 **Alternatives for facilitating the insertion of the guidewire in difficult cases.** Directing it through a ureteral catheter (a), under direct ureteroscopic control (b).

6.3.4. Ensuring Access to the Intramural Ureter

The ureterovesical junction and the intramural ureter constitute the ureteral segment with the smallest caliber, the mean diameter being 3 mm. If the ureterovesical junction is too narrow, it is necessary to use different techniques in order to help pass through the intramural trajectory of the ureter or to dilate the ureteral orifice by different methods.

The latter represents the most frequently used method for facilitating the approach to the intramural ureter, allowing the introduction and extraction of the ureteroscope and of the lithiasic fragments. Moreover, dilation may prevent fixation of the stone or of the ureteroscope in the intramural ureter, thus preventing the risk of terminal ureter avulsion.

Before the miniaturization of rigid and flexible ureteroscopes, ureteral dilation represented a routine maneuver within the intervention's protocol. A study performed by Garvin and Clayman (1991) demonstrated the absence of long-term sequelae after routine dilation of the ureteral orifice with the balloon catheter. Modern low-caliber instruments have reduced the necessity for dilation to approximately 14% of cases (Harmon et al., 1997). This is only required when the ureteral orifice cannot be easily passed or when multiple passages of the ureteroscope are required. Recently, ureteral access sheaths ensure a rapid dilation and allow repeated passages of the ureteroscope.

Dilation of the intramural ureter must be performed up to a diameter adapted according to the caliber of the ureteroscope used. This can be achieved by several active or passive methods.

Progressive, telescopic dilation can be performed using Teflon or polyethylene dilators, from 6 F to 18 F, advanced over a standard 0.038 in. guidewire, inserted cystoscopically. Repeated insertions of the dilators can traumatize the ureteral mucosa and musculature, causing bleeding with consecutive reduction of visibility in the endoscopic field.

An alternative is to use a Nottingham-type progressive cone dilator, with a diameter of up to 12 F (Fig. 6.11). These two methods cannot be applied in cases of steinstrasse syndrome or if the stone is located in the distal ureter.

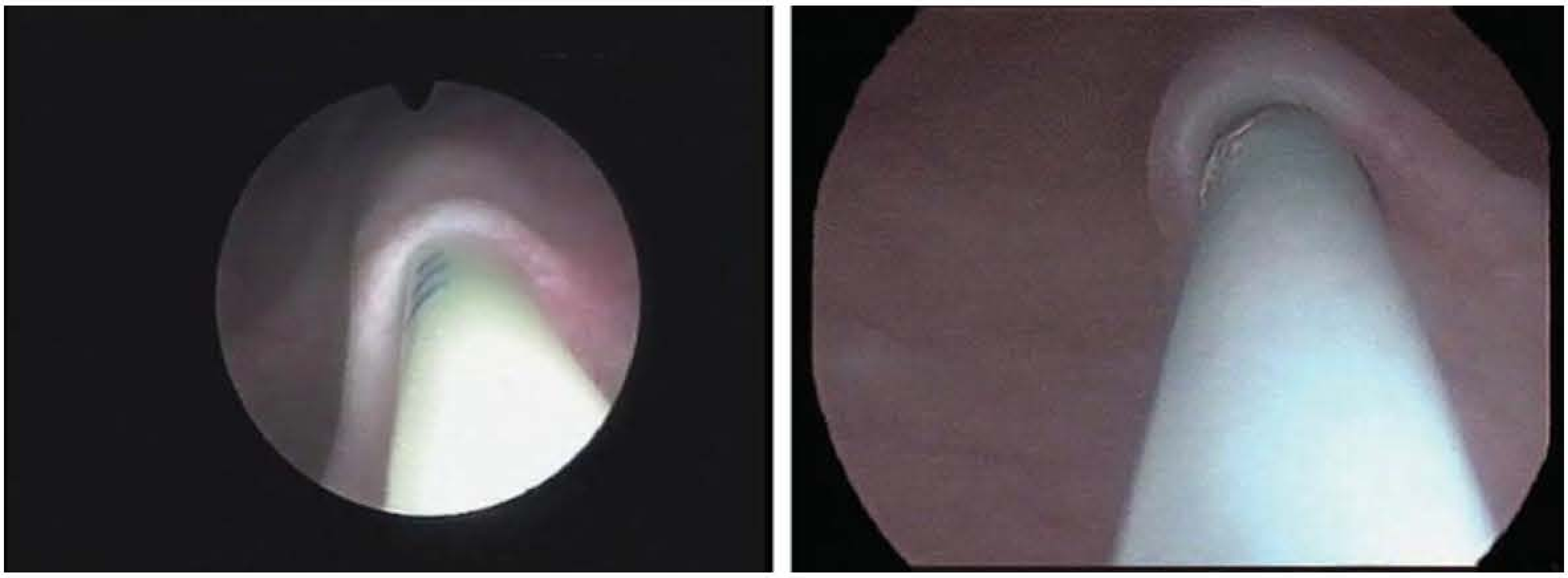


Figure 6.11 **Dilation of the ureteral orifice using a cone ureteral catheter.**

Dilation can also be performed using flexible metallic plugs with an olivary end, with dimensions ranging from 9 F to 13.5 F, passed through the sheath of the rigid cystoscope, over a guidewire ascended anteriorly into the ureter. This dilation method can also be used for juxtavesical pelvic ureteral lithiasis or even for steinstrasse syndrome. Another alternative is represented by dilation through coaxial systems of ureteral access, over which the working sheath is advanced.

Hydraulic dilation of the ureter using the Uromat represents an efficient procedure, which consists of achieving, through a hydraulic pump, an irrigation stream of up to 200 mm Hg. If the procedure does not have a long duration, the hyperpressure in the urinary tract does not determine adverse effects.

Passive dilation by placing a ureteral catheter or a stent for 48–72 h (Fig. 6.12) was described by Perez-Castro and Martinez-Pineiro (1982).

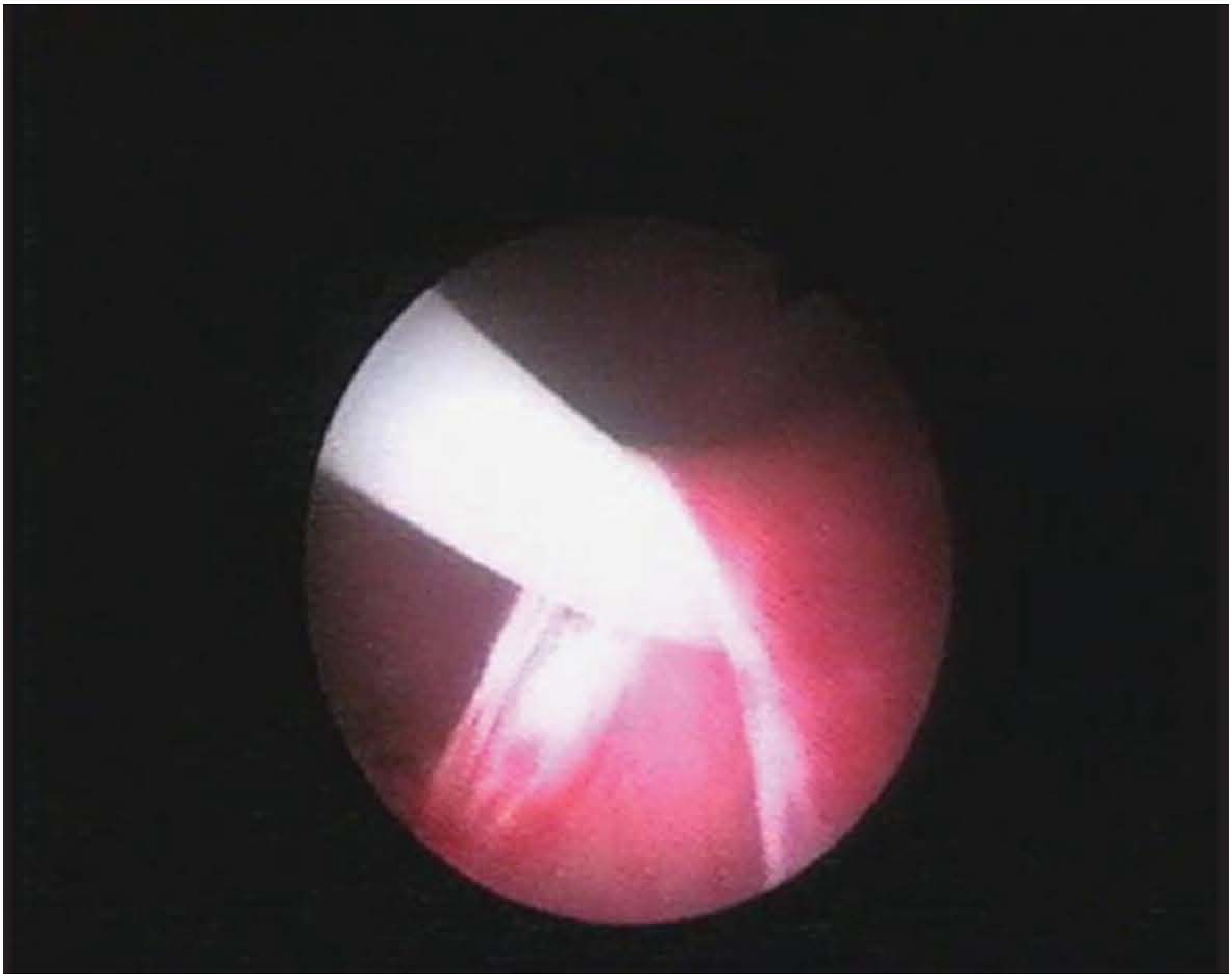


Figure 6.12 **Ureteral orifice passively dilated with a JJ stent.**

However, this technique presents several disadvantages. The most important is the fact that it transforms the ureteroscopy into a two-step procedure, determining an increase in duration and in hospitalization costs. It also increases the risk of urinary infections and may determine the stone's mobilization.

The presence of ureteral stenoses, of an impacted ureteral stone, or of steinstrasse syndrome may prevent achieving passive dilation, requiring performing a percutaneous nephrostomy. The balloon catheter represents the most frequently used instrument for dilating the intramural ureter (Fig. 6.13).

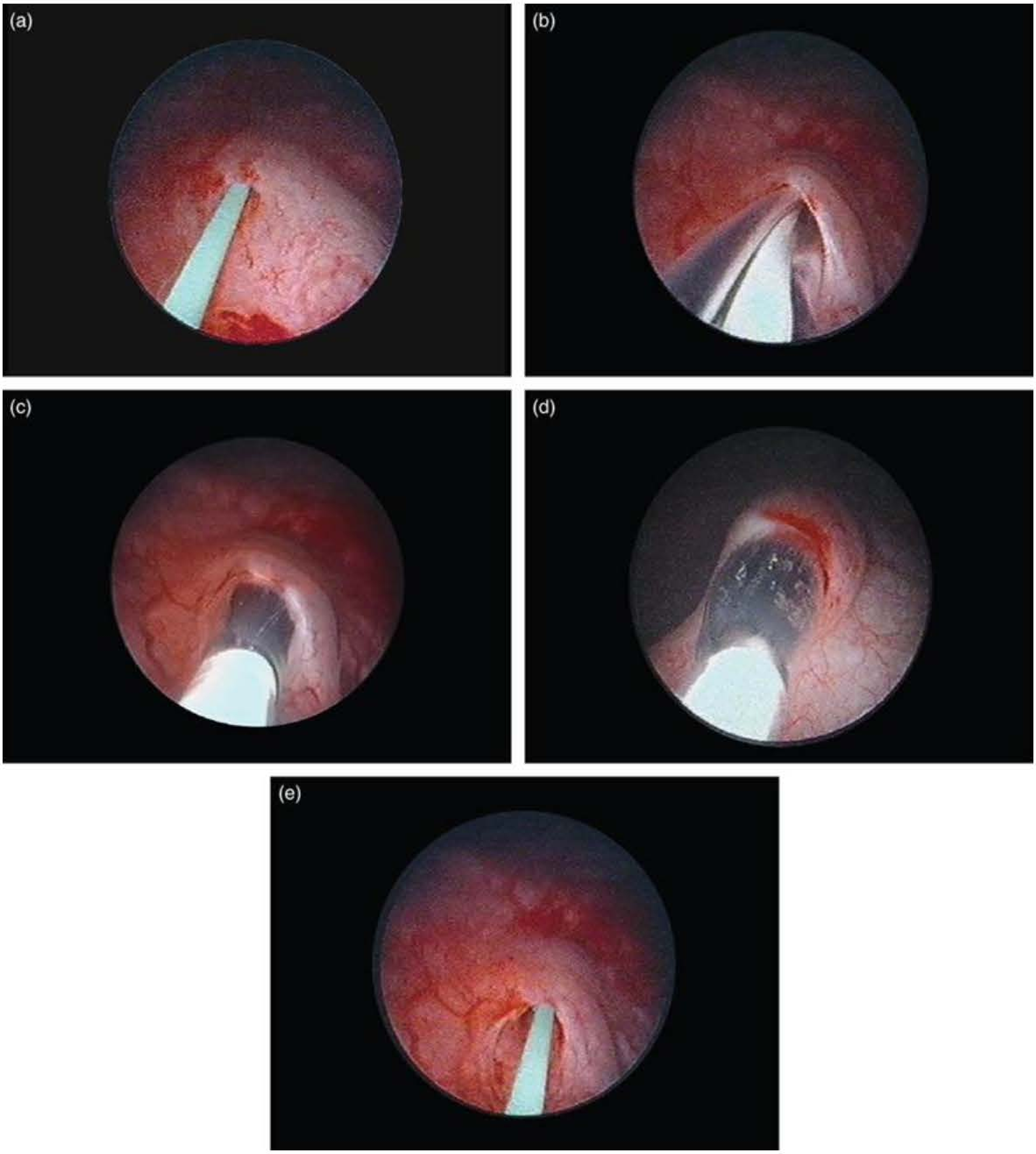


Figure 6.13 **Dilation of the ureteral orifice using the balloon catheter.**
Insertion of the guidewire (a), positioning of the balloon catheter (b), inflation of the balloon (c, d), aspect of the ureteral orifice after dilation (e).

This has radiopaque marks at the two extremities of the balloon and is introduced into the ureter through a guidewire placed anteriorly up to the renal pelvis. The balloon is inflated using a normal 5 mL syringe or a LeVeen-type syringe that allows pressure control; 2–5 mL of 30–50% contrast media can be introduced, allowing the fluoroscopic control of the maneuver. The balloon is inflated slowly (1–2 atm/min) in order to prevent its rupture or the rupture of the ureter. The maximum inflation pressure should not exceed 15 atm. The inflation of the balloon continues until it takes a cylindrical shape, without strangulation rings.

Correctly performed, the balloon dilation of the ureter is a relatively nontraumatic maneuver, ensuring safe access to the upper urinary tract (Clayman, 1987). Ureters dilated to diameters of 15–18 F can heal completely. After ureteral dilation, a transient degree of vesicoureteral reflux can occur, without long-term clinical significance (Perez-Castro and Martinez-Pineiro, 1982). Lesions of the mucosa and subsequent leakage of the contrast media were observed in 52%, respectively 19% of patients in whom balloon dilation up to 24 F was performed (Garvin and Clayman, 1988). Placing a ureteral stent after the procedure contributes to preventing the occurrence of secondary ureteral stenoses (Boddy et al., 1988).

In exceptional situations, when dilation of the intramural ureter is impossible using the aforementioned procedures, an endoscopic incision of the ureteral orifice can be performed (Fig. 6.14). The balloon dilators currently used have variable sizes, with a balloon diameter ranging from 3 F to 30 F, and with a length between 4 cm and 20 cm.

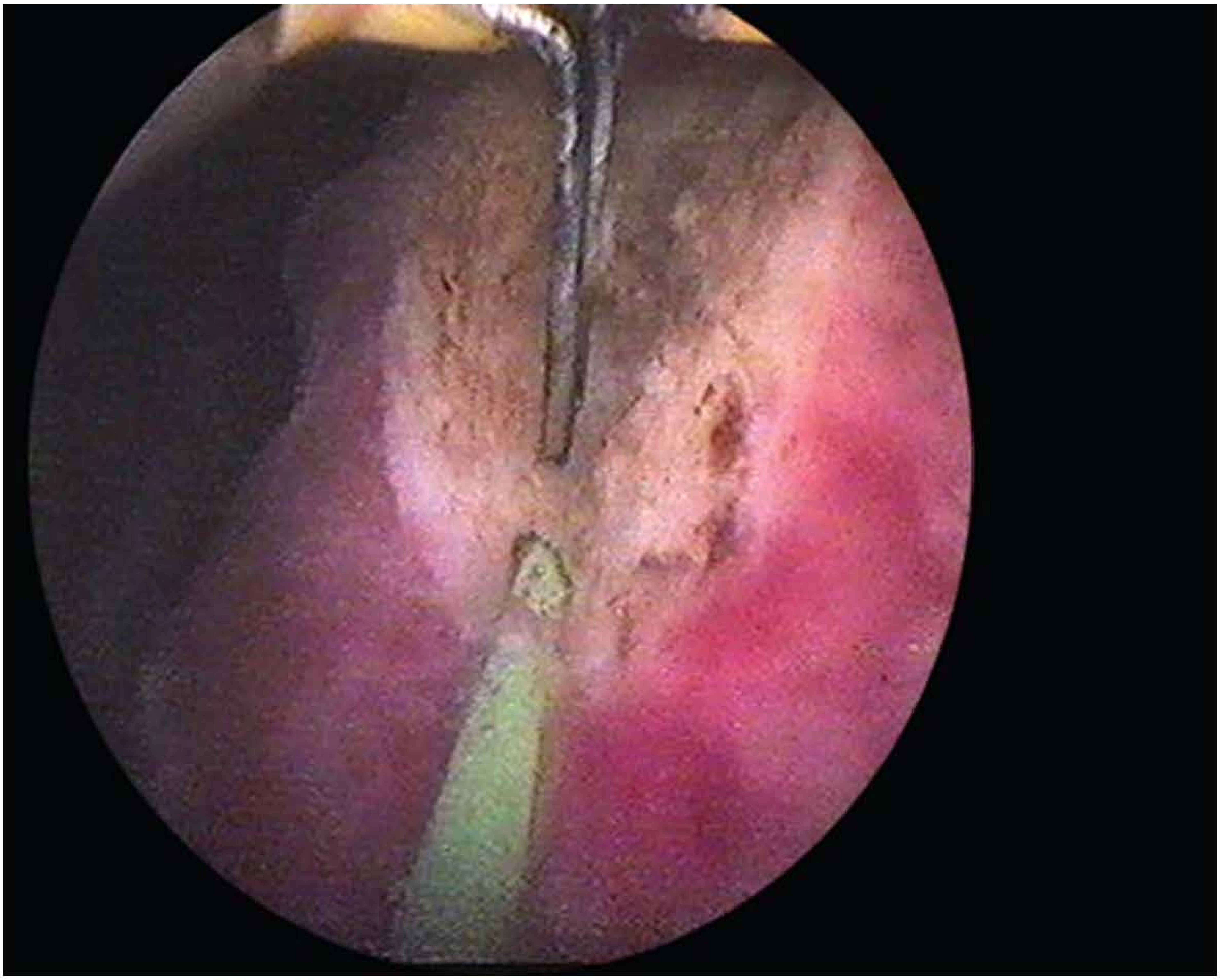


Figure 6.14 **Incision of the stenosed ureteral orifice using a Collins loop.**

The approach to the intramural ureter can be facilitated by using two guidewires ascended through the ureter, and the endoscope can be easily oriented between them (Fig. 6.15). The method removes the necessity for dilating the ureteral orifice, the maneuver being much less traumatic (without requiring postoperative ureteral stenting) and less expensive (Geavlete et al., 2005a).

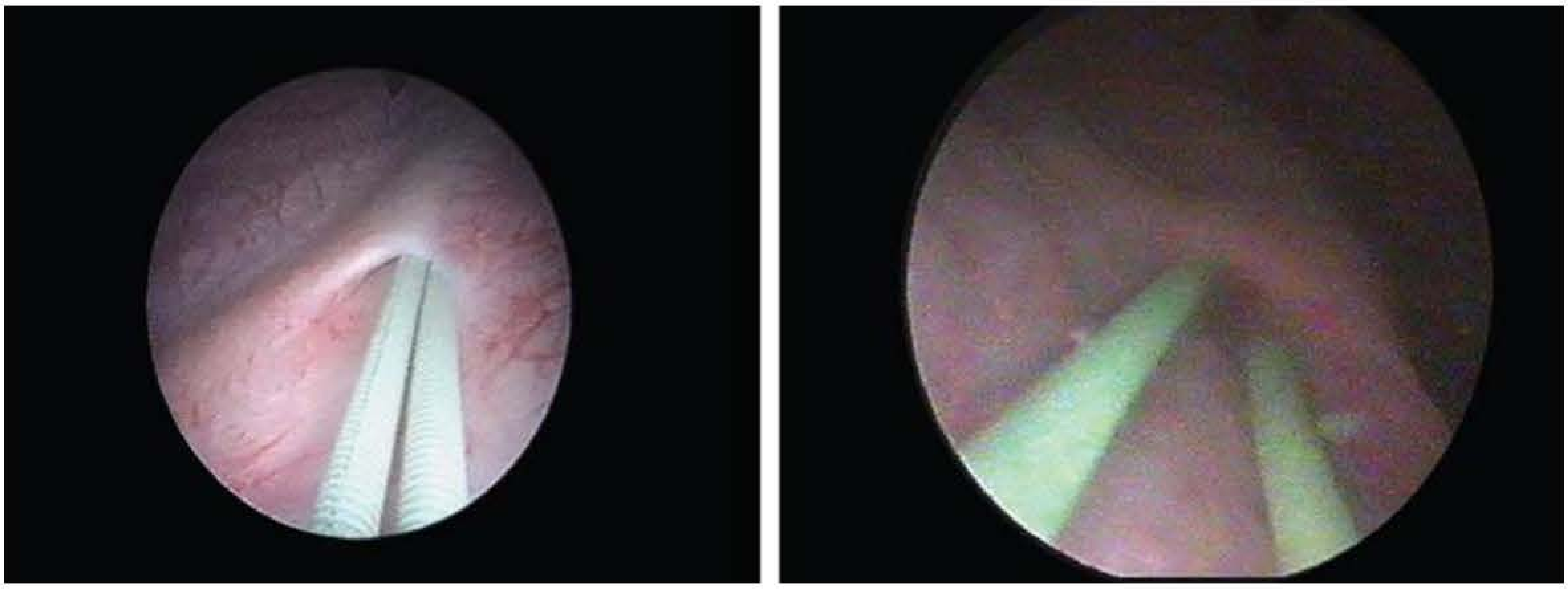


Figure 6.15 **Passing the ureteral orifice with two guidewires.**

Another alternative for facilitating the access to the upper urinary tract is represented by using the ureteral access sheath. Its most important indication is represented by the ureteroscopic treatment of large renal or proximal ureteral calculi. The sheath is chosen according to the patient's constitution, the localization of the stone, and the caliber of the ureteroscope used.

The procedure has two important advantages: minimalization of ureteral trauma (by repeated insertions of the ureteroscope) and the hypopressure in the overlying urinary tract (which reduces the infectious risk and that of the patient's hyperhidration) (Monza et al., 2001). The use of the access sheath allows for maintaining a reduced pressure (below 30 cm H_2O) in the pyelocaliceal system, even while using an increased irrigation flow (Rehman et al., 2003).

On the other hand, some authors consider that the potential disadvantages can contraindicate the use of the ureteral access sheath. As opposed to balloon dilation, the placing of the sheath determines the exertion of scissoring forces in the distal ureter, which may increase the risk of stenoses at this level. Although long-term evaluations indicate a reduced rate of these ureteral strictures (Vanlangendonck and Landman, 2004), controlled studies are still necessary in order to assess the long-term effects (Abrahams and Stoller, 2004).

The access sheath occupies a part of the internal diameter of the ureter, its interior caliber being approximately 2 F smaller than the external one. For this reason, a dilation up to a larger diameter compared to classic ureteroscopy is required. This may determine the reduction of the blood flow at the level of the ureteral wall by approximately 65% when 14–16 F sheaths are used (Lallas et al., 2002). For this reason, it is recommended to avoid using sheaths in patients with a history of radiotherapy or retroperitoneal interventions. The potential risk of ureteral ischemia increases in cases that require prolonged interventions. If the sheath is placed only under fluoroscopic control, stone fragments or tumors located in the distal ureter may not be observed.

Certain associated pathological modifications (e.g., large prostatic adenomas) may make placing the access sheath impossible or may deform it, preventing the facile insertion of the ureteroscope (Abrahams and Stoller, 2004).

Moreover, due to the large-scale introduction of laser lithotripsy, which allows for fragmentation of stones into very fine particles, fewer and fewer retrograde ureteroscopic procedures require repeated excursions into the upper urinary tract (Abrahams and Stoller, 2004).

The use of the ureteral access sheath determines additional costs. However, a recent analysis of their use has shown a reduction of the operative time and, implicitly, of the procedure's costs (Kourambas et al., 2001).

6.3.5. Ascending the Ureteroscope

Rigid or semirigid ureteroscopy begins by advancing the ureteroscope under direct visual control, along the guidewire, up to the urinary bladder. The ureteral orifice is then approached, the ureteroscope being advanced under visual and fluoroscopic guidance.

The ureteroscope is introduced into the intramural ureter by raising the superior margin of the orifice with its distal end by using one of the following procedures:

- fixing the ureterescope perpendicular to the ureteral orifice, followed by lowering it by 90°, associated with its advance in the direction of the intramural trajectory
- simultaneously exerting a lowering (90°) and twisting (180°) motion

- twisting the ureterescope fixed at the level of the ureteral orifice (180°)

Once advanced into the intramural ureter, the ureteroscope is brought back to its initial position.

The following rules must be respected when negotiating the ureteral orifice and ascending the endoscope:

- the introduction of the endoscope into the ureter must be performed under direct visual control, always maintaining the ureteral lumen in the center of the endoscopic field (Fig. 6.16)

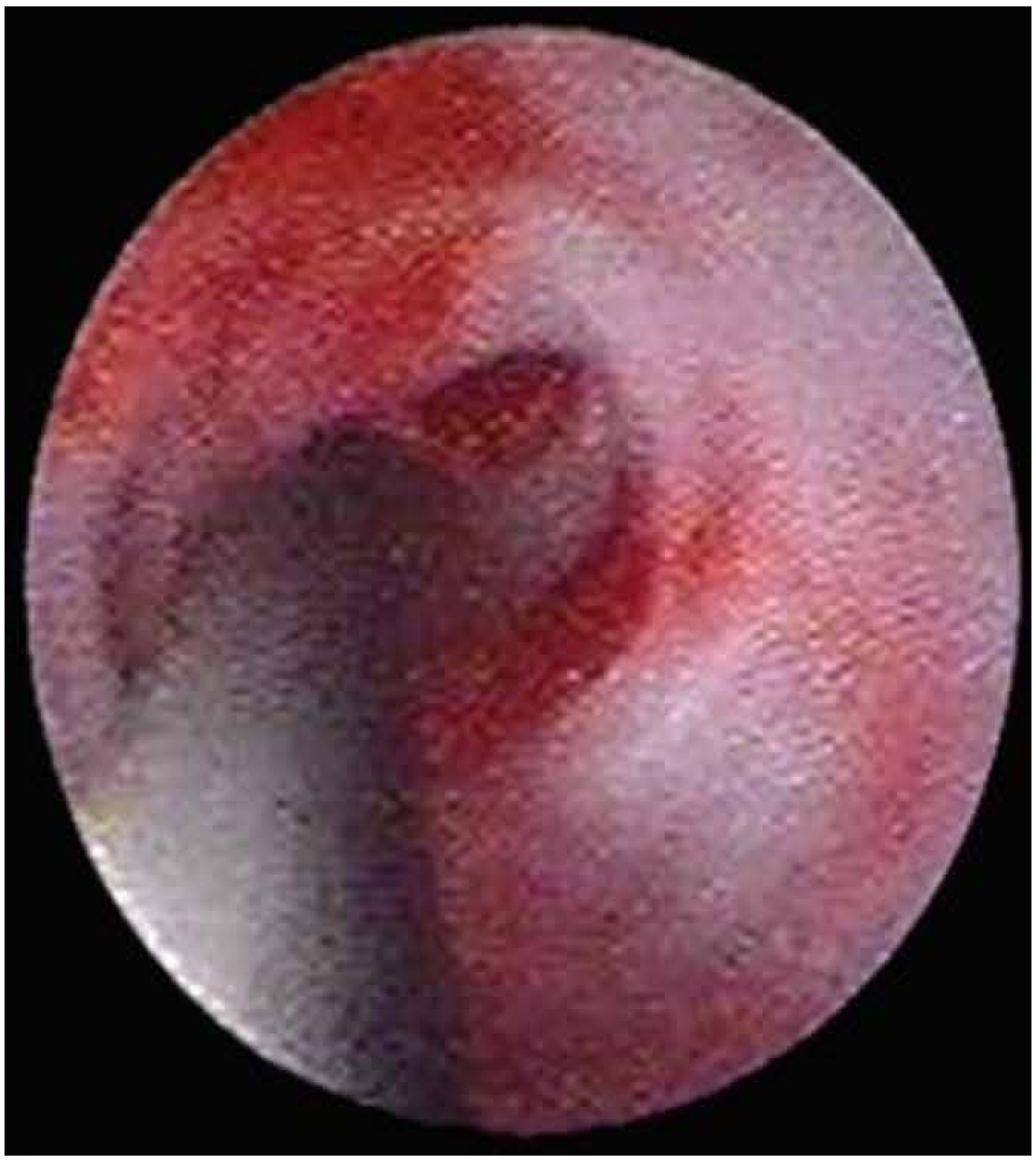


Figure 6.16 **Ascending the ureteroscope into the intramural ureter.**

- the endoscope is advanced proximally only if the ureteral lumen is clearly seen, and if the instrument slides easily along the lumen

The proximal advancing of the ureteroscope will be done without exerting excessive pressure, permanently keeping the guidewire in the center of the endoscopic field (Fig. 6.17). Thus, the occurrence of ureteral perforations can be prevented.

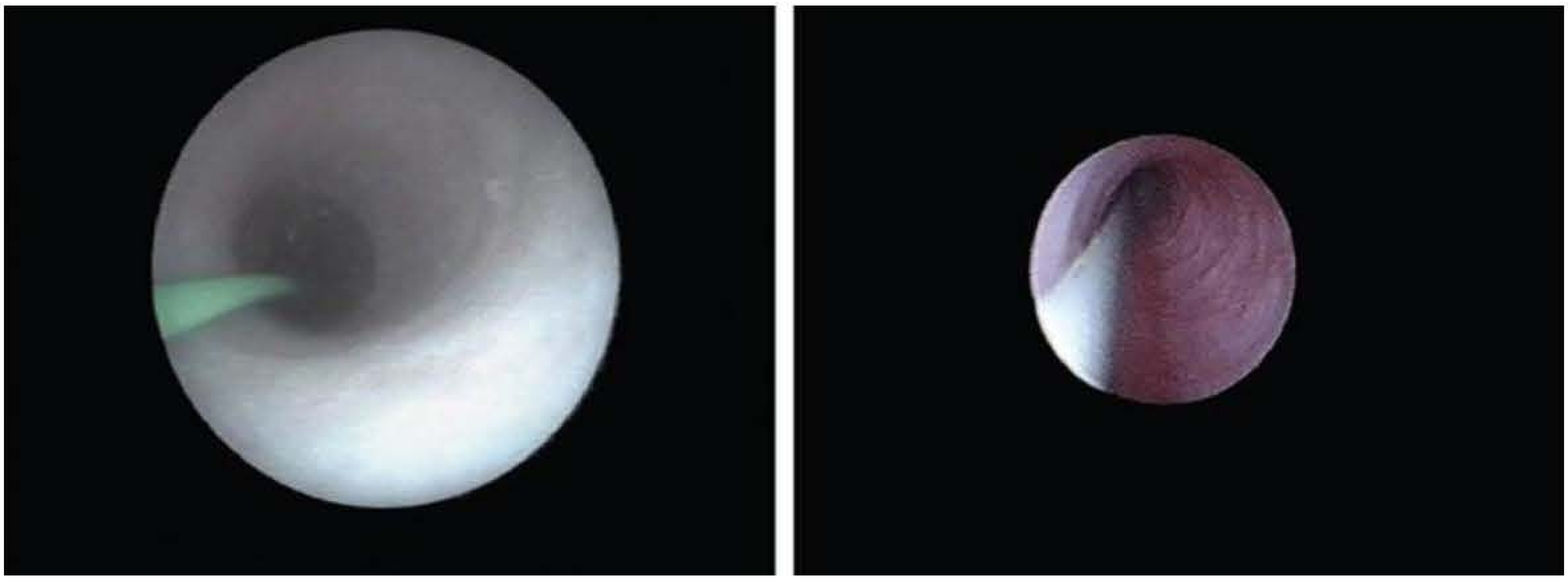


Figure 6.17 **Advancing the ureteroscope into the ureter.**

Some authors do not recommend the routine use of the safety guidewire (Fig. 6.18).

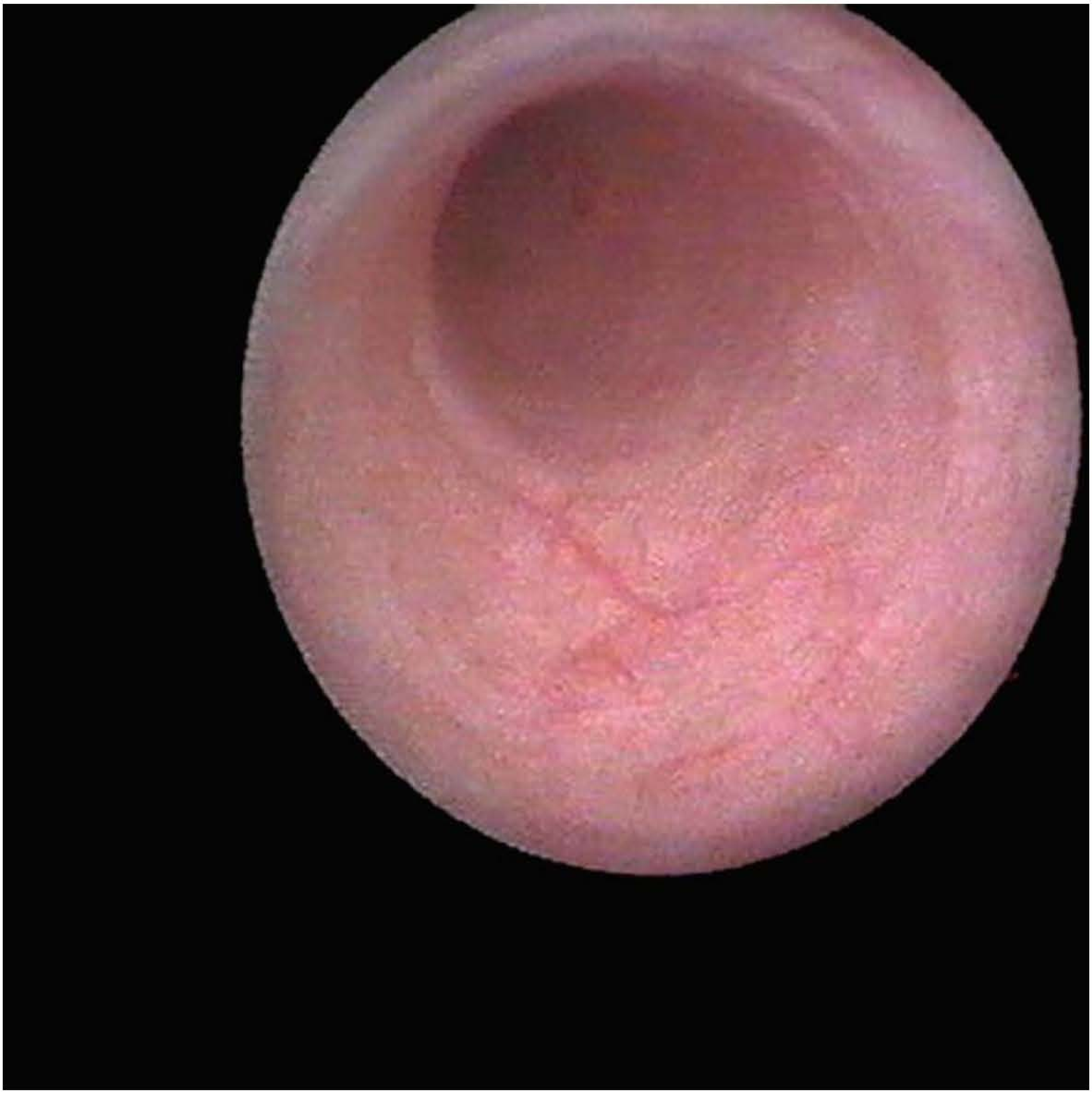


Figure 6.18 **Ascending the ureteroscope without a safety guidewire.**

Knowing the ureter's anatomy and anticipating its curves facilitate the ascent of the ureteroscope. Thus, the progression of the rigid endoscope is more difficult at the level of the iliac vessels. In women, it is easier to advance the rigid endoscope along the entire length of the ureter.

As long as a minimal effort is exerted in order to achieve the proximal advancement of the ureteroscope, the endoscopic field remains round. Its deformation into a half-moon reflects the exertion of an excessive force on the instrument.

Sometimes, the advancement of the ureteroscope may be more difficult due to the following reasons:

- reduced visibility due to bleeding
- reduced ureteral caliber
- ureteral sinuosities

Regaining a clear endoscopic field may be achieved by increasing the irrigation flow, by facilitating the evacuation of the irrigation fluid, or sometimes even by removing the optics until the fluid evacuated through the endoscope's sheath becomes clear. Another method is injecting saline solution through a ureteral catheter introduced up to the distal end of the endoscope.

The narrower areas of the ureter (Fig. 6.19) can be dilated using balloon catheters. The dilator can be advanced on the guidewire up to the narrow area that has been observed by fluoroscopy. Dilation is achieved using a technique similar to that used in the dilation of the ureteral orifice. If elimination of the obstruction fails, either ureteral stenting for several weeks or endoureterotomy is recommended. Ureteral sinuosities or narrowed areas of the ureter can prevent performing rigid and semirigid retrograde ureteroscopy in approximately 10% of cases.

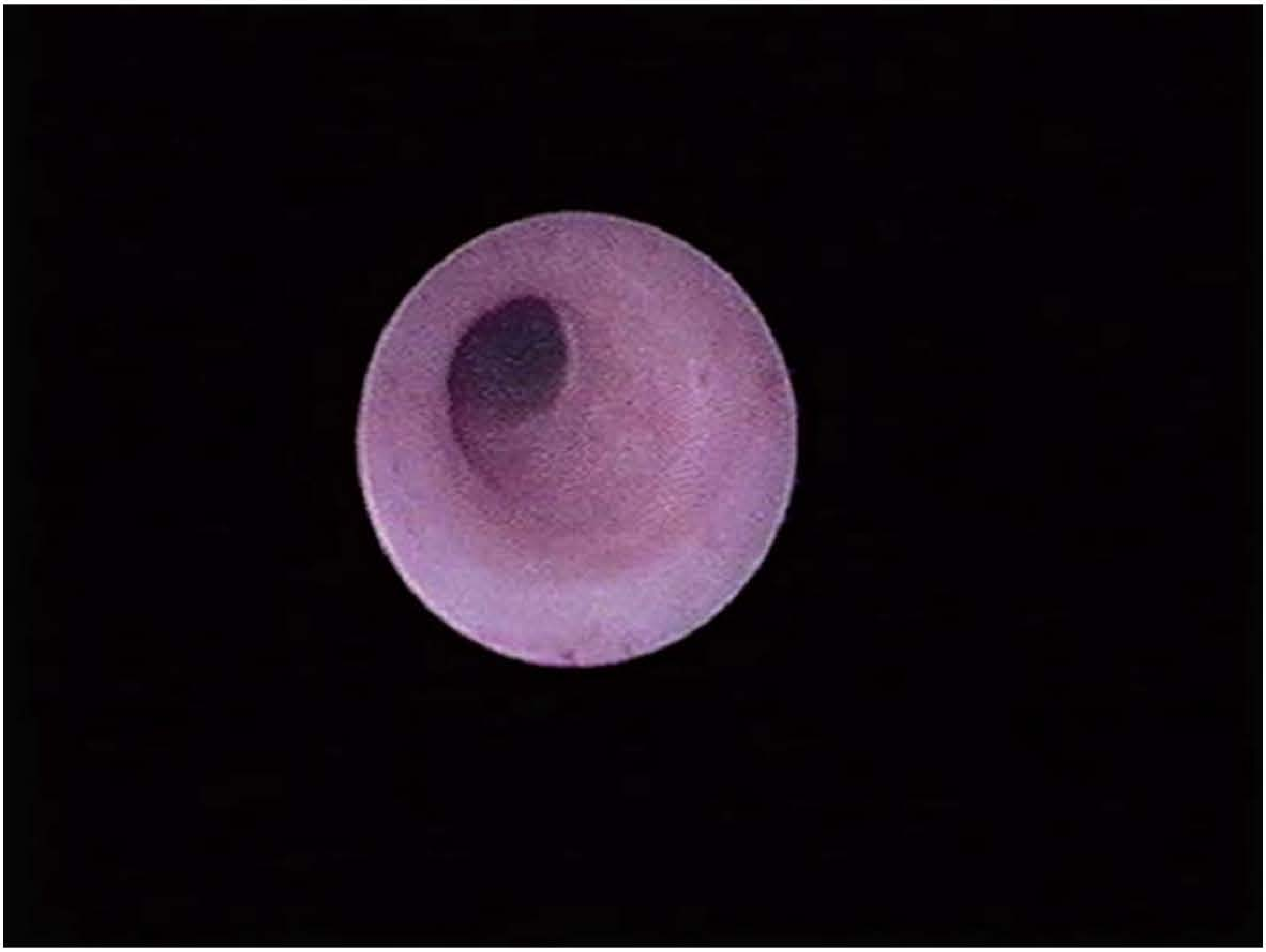


Figure 6.19 **Area of the ureteral lumen with a reduced caliber.**

The tortuous parts of the ureter (Fig. 6.20) can raise technical difficulties.

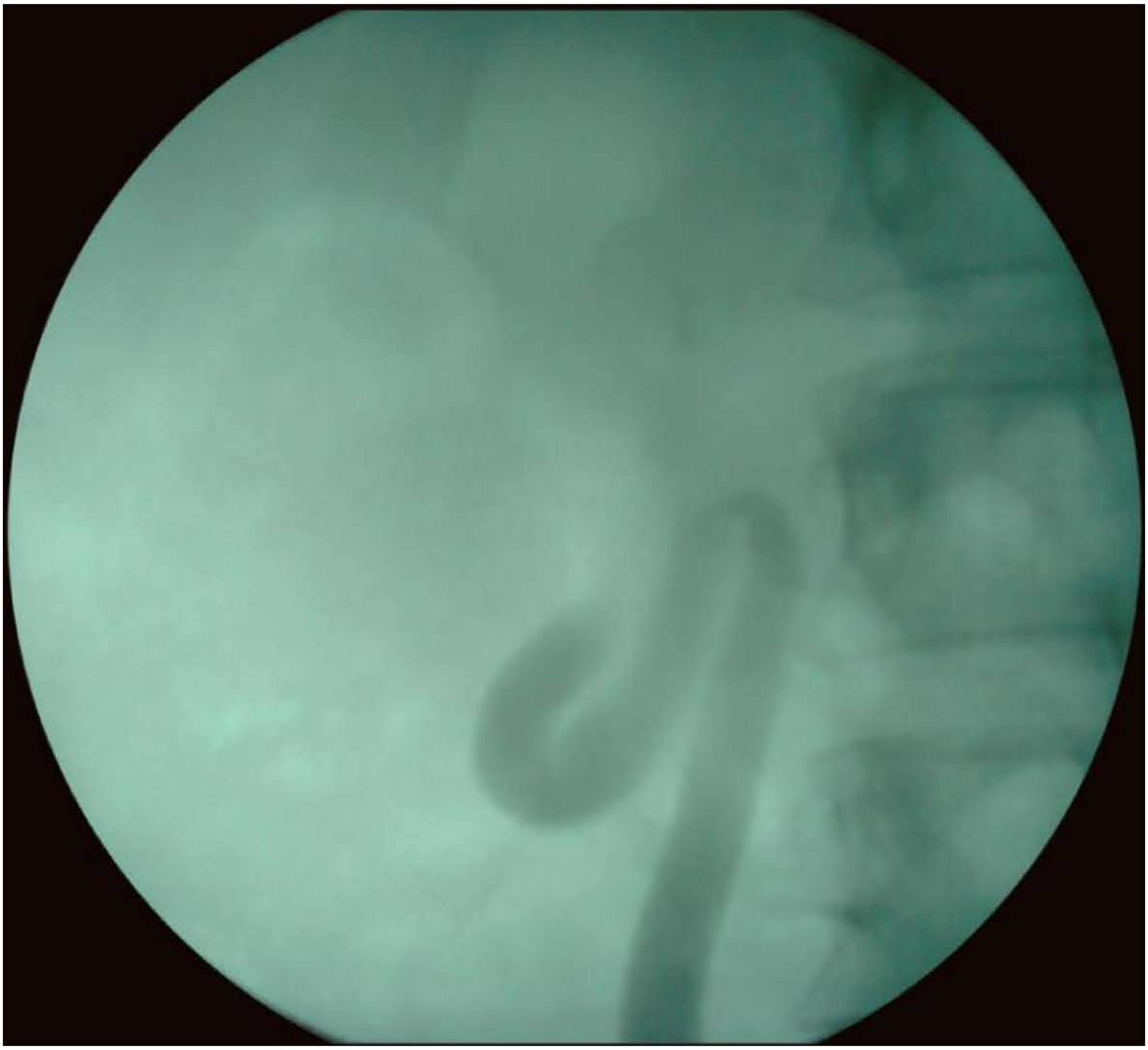


Figure 6.20 **Tortuous ureteral segment (fluoroscopic aspect).**

Ureteral sinuosities can be passed by using one or more of the following maneuvers:

- Negotiating the area by orienting the tip of the endoscope according to the sinuosity, so that the ureteral lumen is kept in the center of the endoscopic field (Fig. 6.21).

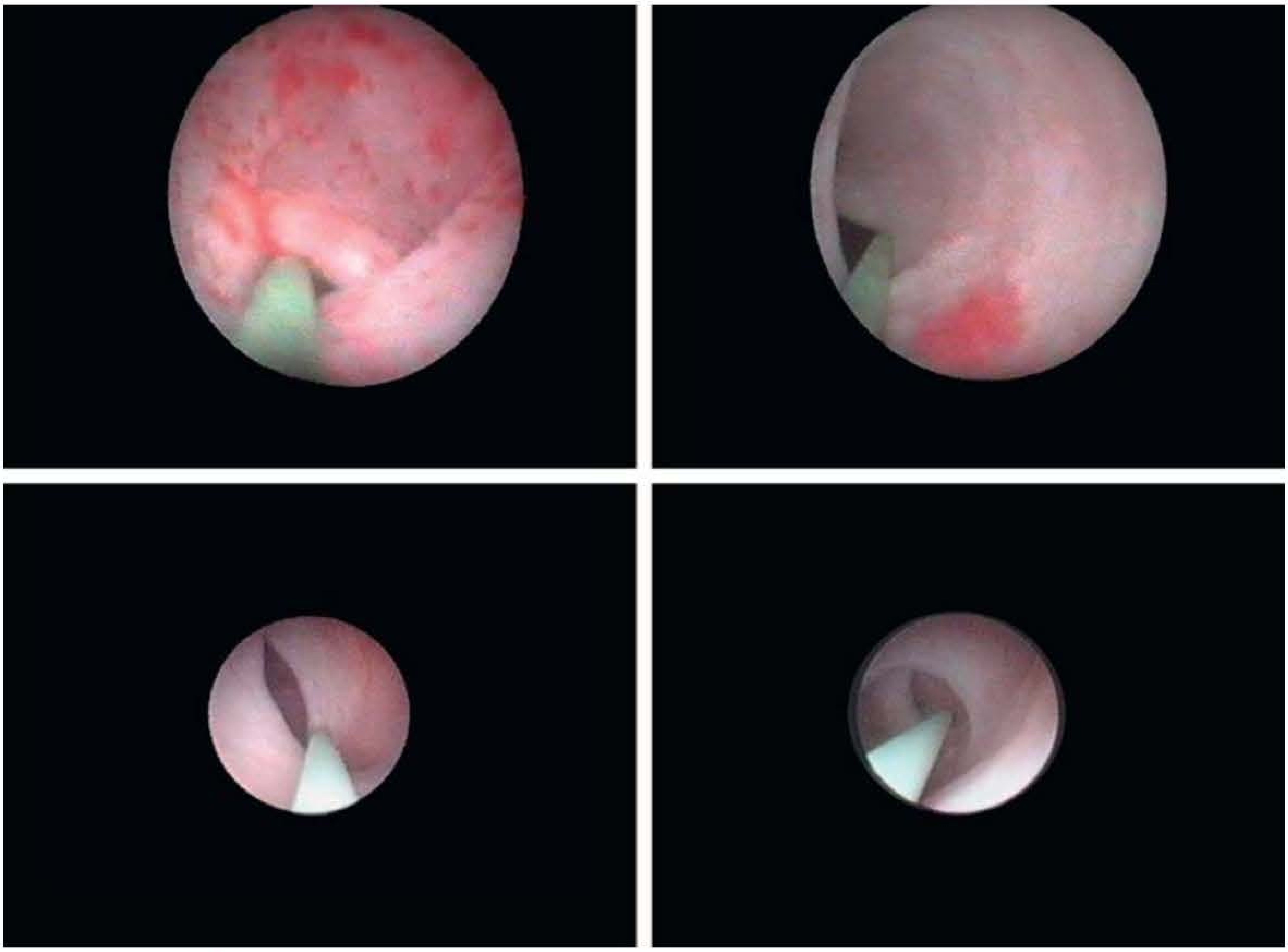


Figure 6.21 **Negotiating the ureteral sinuosities with the semirigid ureteroscope.**

- Positioning the patient in Trendelenburg with ascension of the kidney and alignment of the proximal ureter. This maneuver is inefficient in the presence of pyelonephritis, which determines fixation of the kidney.
- Ascending a ureteral catheter or a rigid guidewire up to the renal pelvis, thus obtaining an alignment of the ureter.
- Advancing a second guidewire through the ureteroscope's working channel. The endoscope is rotated so that it is placed between the two guidewires, which therefore contributes to the opening and alignment of the ureter, facilitating the passage (Fig. 6.22).

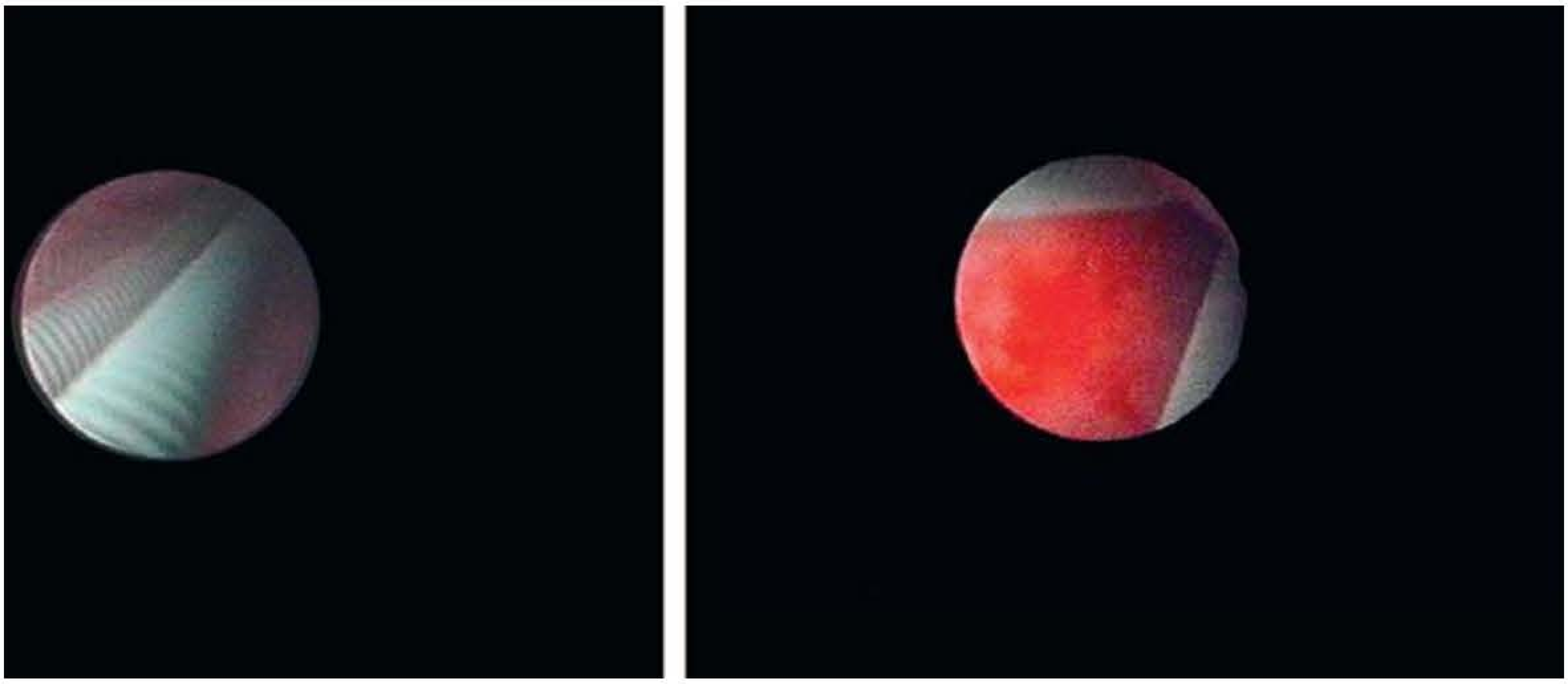


Figure 6.22 **Passing a ureteral sinuosity by using two guidewires.**

6.3.6. Extraction of Ureteral Calculi

The modality of removing ureteral stones depends both on their dimensions and location, as well as on the status of the underlying and overlying urinary tract.

The extraction of unimpacted ureteral calculi is achieved according to their dimensions. Those with a size under 6 mm can be extracted with a forceps or a balloon catheter, without requiring their fragmentation (Figs 6.23 and 6.24).

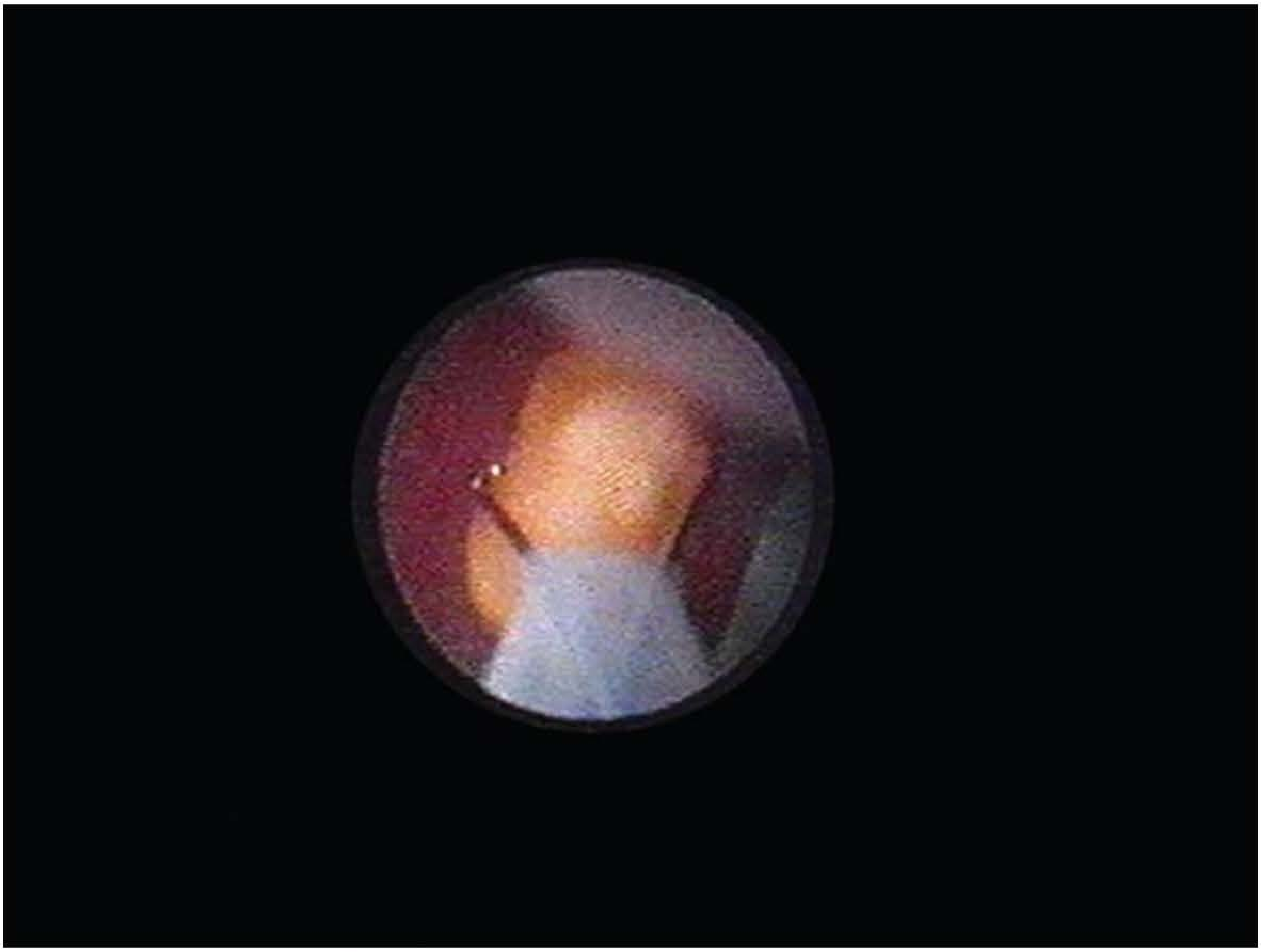


Figure 6.23 **Extracting a stone with the tripod grasper.**

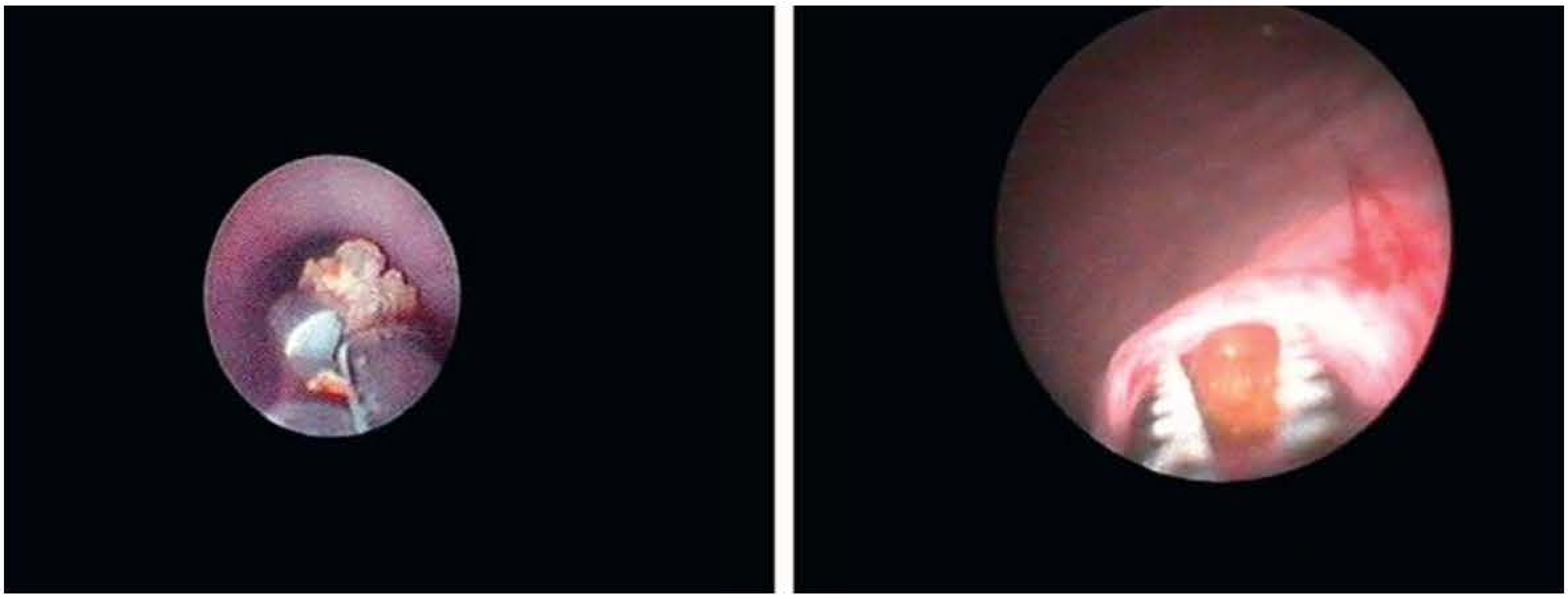


Figure 6.24 **The extraction of small ureteral calculi with a forceps.**

After catching the stone between the spirals of the Dormia catheter, it is withdrawn concomitantly with the ureteroscope (Fig. 6.25). If stone impaction is observed during the extraction, the maneuver must be stopped in order to avoid lesions or avulsion of the ureter.

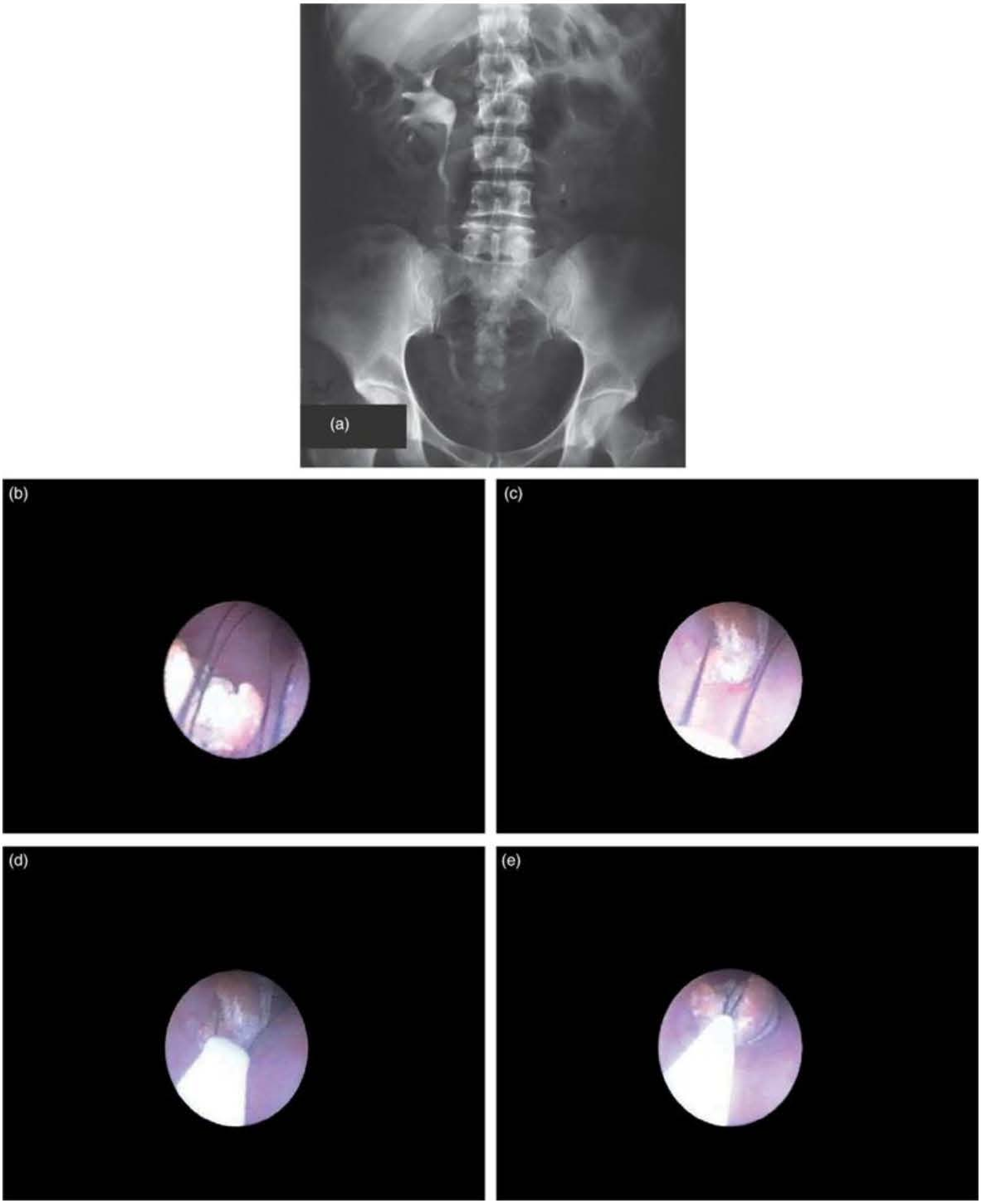
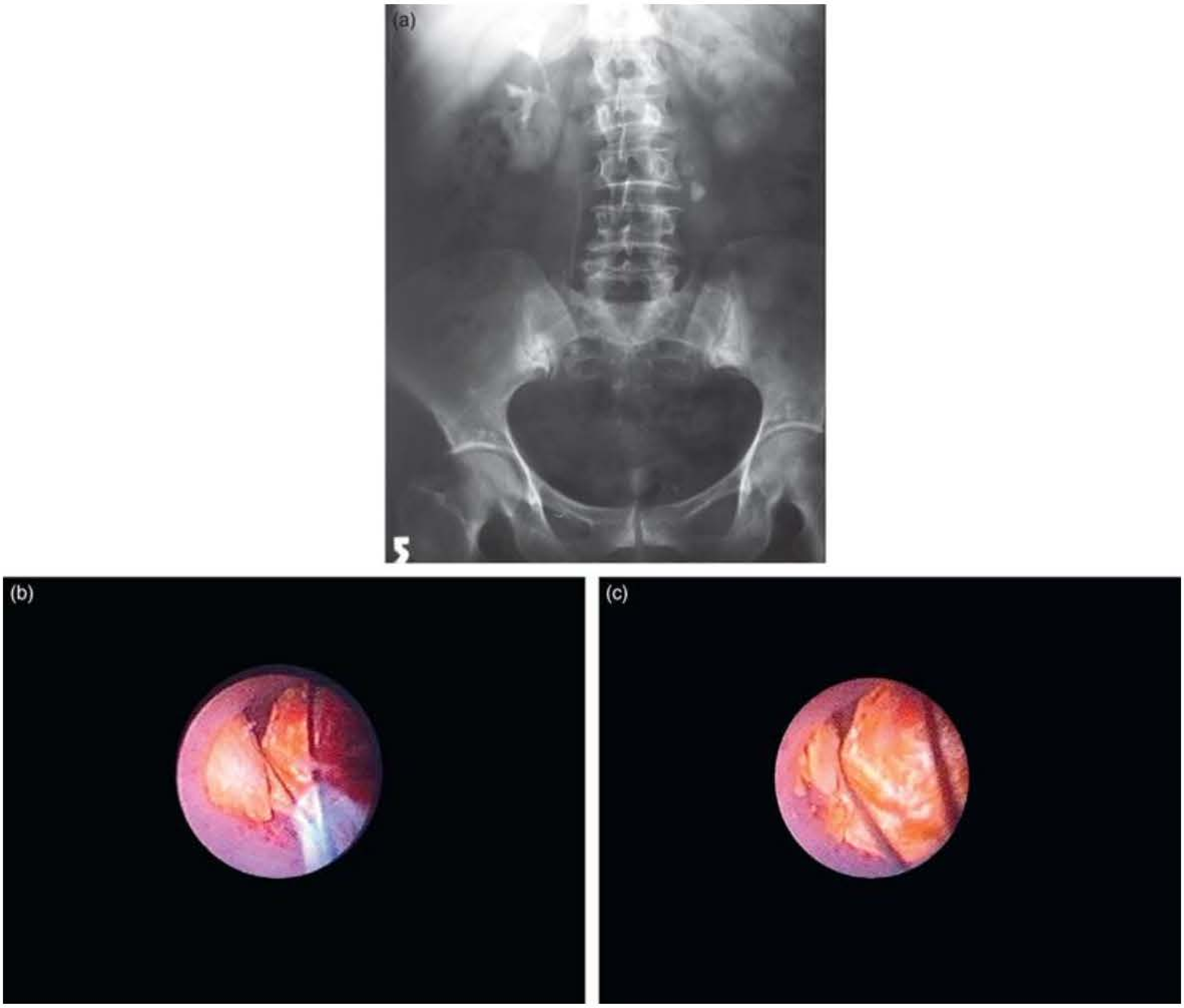


Figure 6.25 **Left lumbar ureteral stone (a), extracted with a basket catheter under direct visual control (b–e).**

In this case, the lithotripsy probe is introduced through the working channel in order to process the stone between the probe's spirals, and only after that can the fragments be extracted safely.

Stones larger than 6 mm will be extracted only after intracorporeal lithotripsy. Due to the risk of proximal migration, fragmentation will be achieved after immobilization of the stone with a special balloon catheter or with a basket catheter introduced through the endoscope's secondary working channel (Fig. 6.26).


(a)
5
(b)
(c)

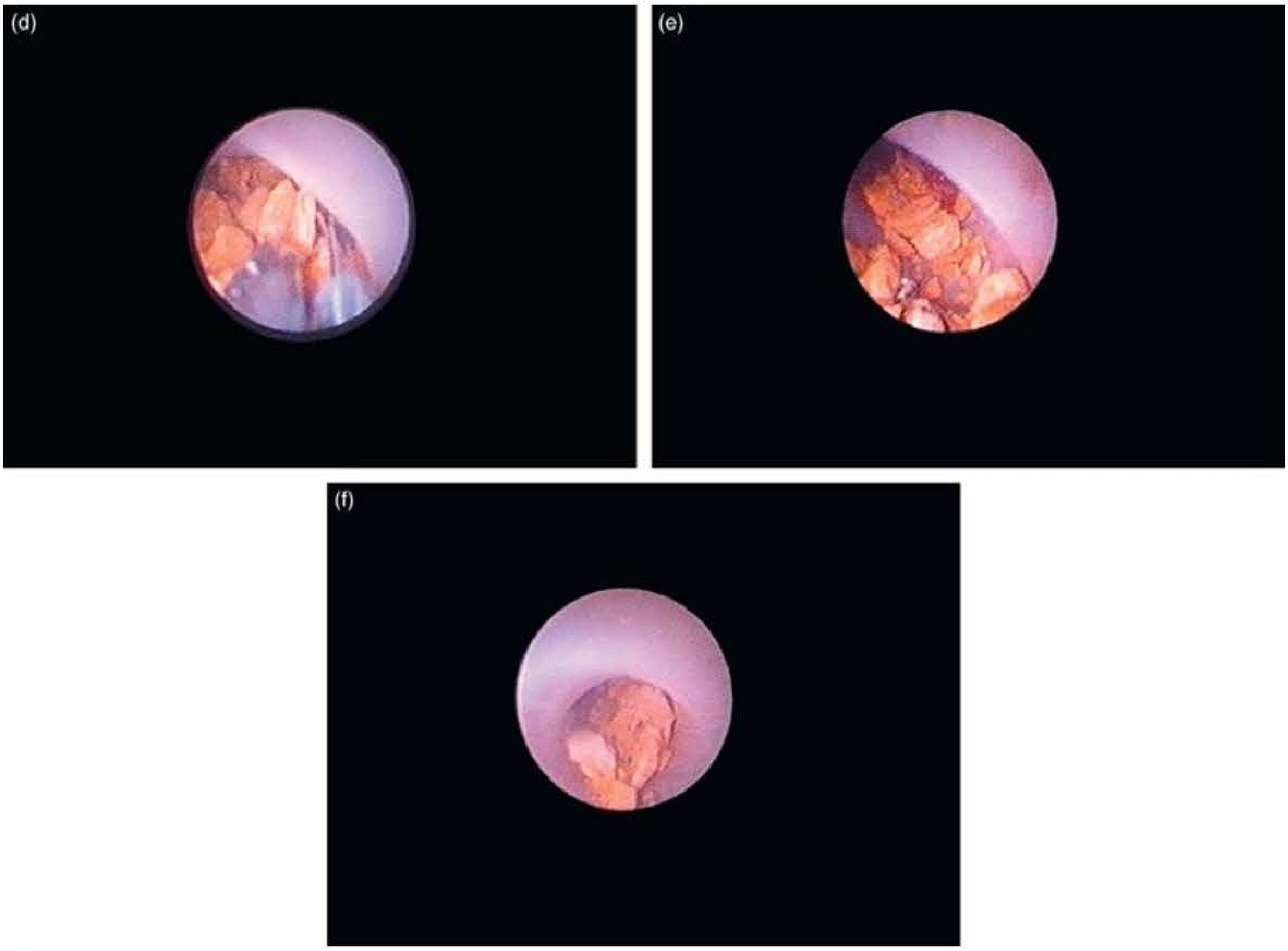


Figure 6.26 **Large obstructive left lumbar ureteral stone (a), balistically fragmented between the spirals of the basket catheter (b–f).**

Fixation of the stone can also be achieved with the 5 F ureteral catheter ascended through the central working channel or by using the Detler cone, advanced above the stone.

Impacted stones, which have a reduced risk of proximal migration, can be extracted after fragmentation *in situ* (ultrasonic, electrohydraulic, pneumatic, or laser).

In order to allow the complete and complication-free elimination of the fragments, lithotripsy must be performed up to dimensions smaller than the guidewire's diameter (0.035 in.).

As an alternative method, lithotripsy of the stone can be done into fragments that can be completely removed with extraction instruments (Fig. 6.27). The presence of small, but removable, lithiasic pieces at the end of the procedure requires ureteral stenting.

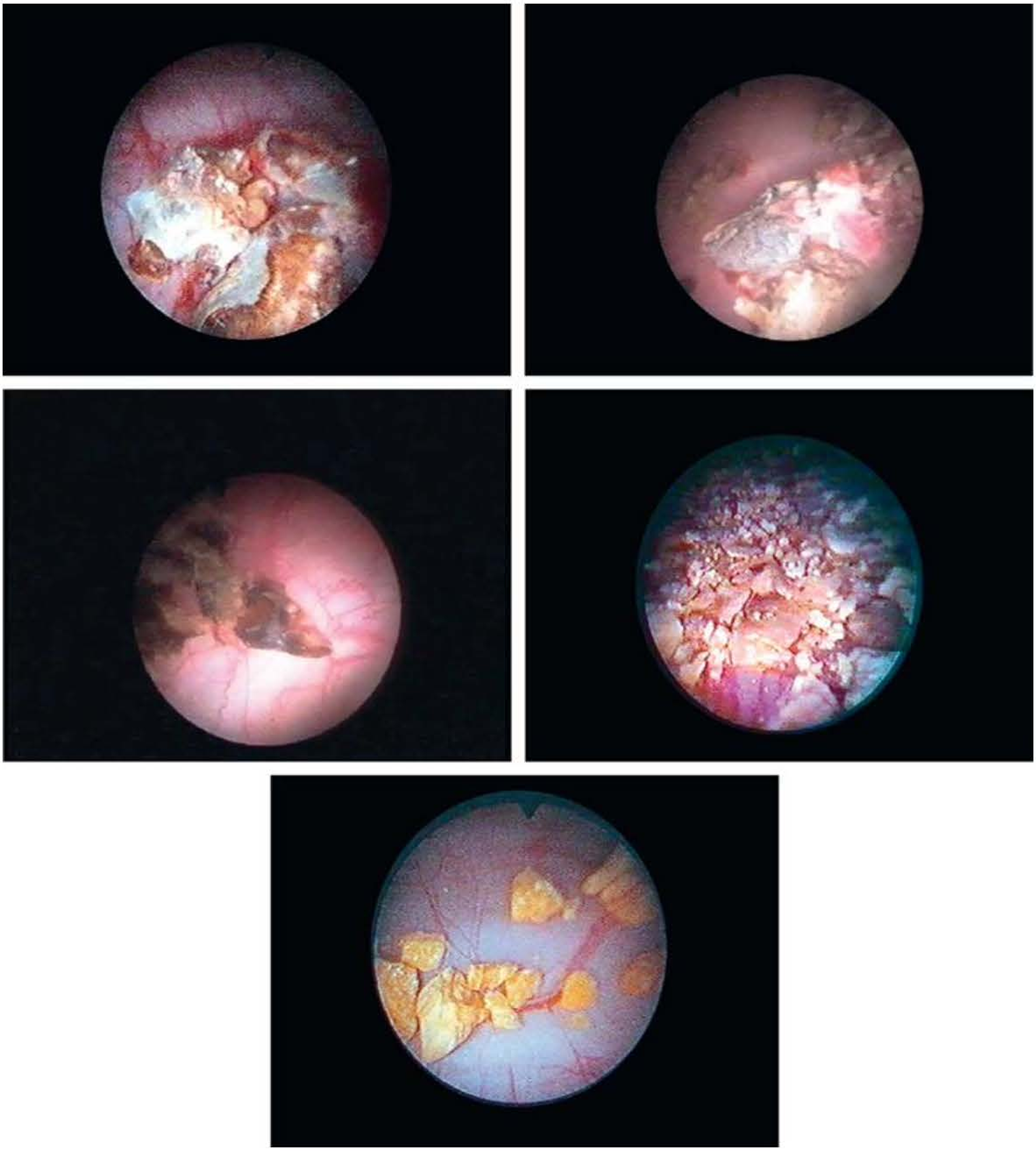


Figure 6.27 **Ureteral lithiasic fragments evacuated into the urinary bladder.**

A series of technical difficulties are raised by the treatment of soft ureteral calculi, especially due to the particularities of the extracting instruments with a design conceived for manipulating rough lithiasic fragments (Geavlete et al., 2006a). Extraction of this type of calculi is done especially using basket catheters (Figs 6.28 and 6.29).

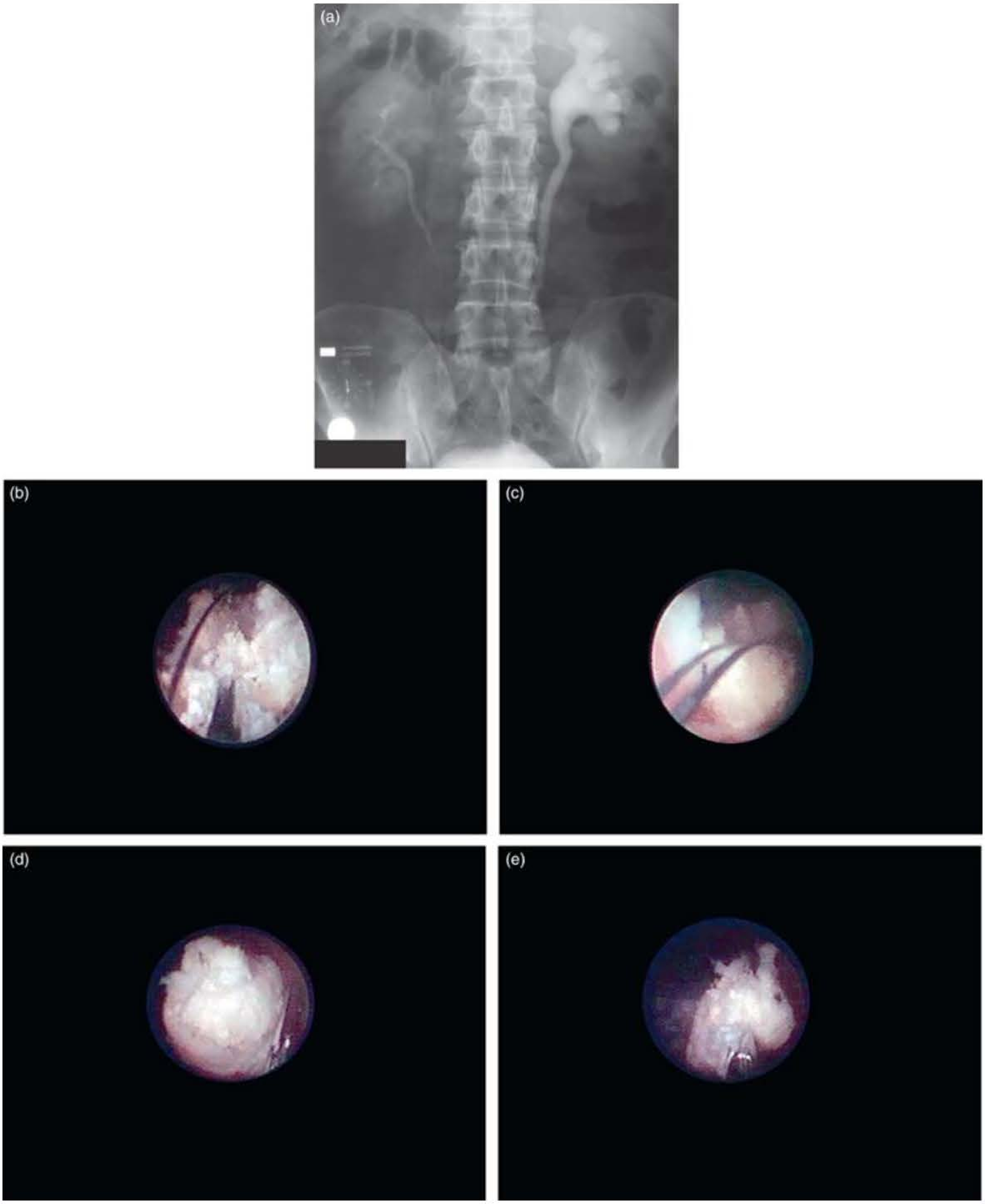


Figure 6.28 Retrograde ureteroscopic approach of a soft ureteral stone. Left hydronephrosis secondary to pelvic ureteral obstruction (intravenous urography) (a), extraction of the stone with the basket catheter (b, c), extraction of the remaining fragments with a forceps (d, e).

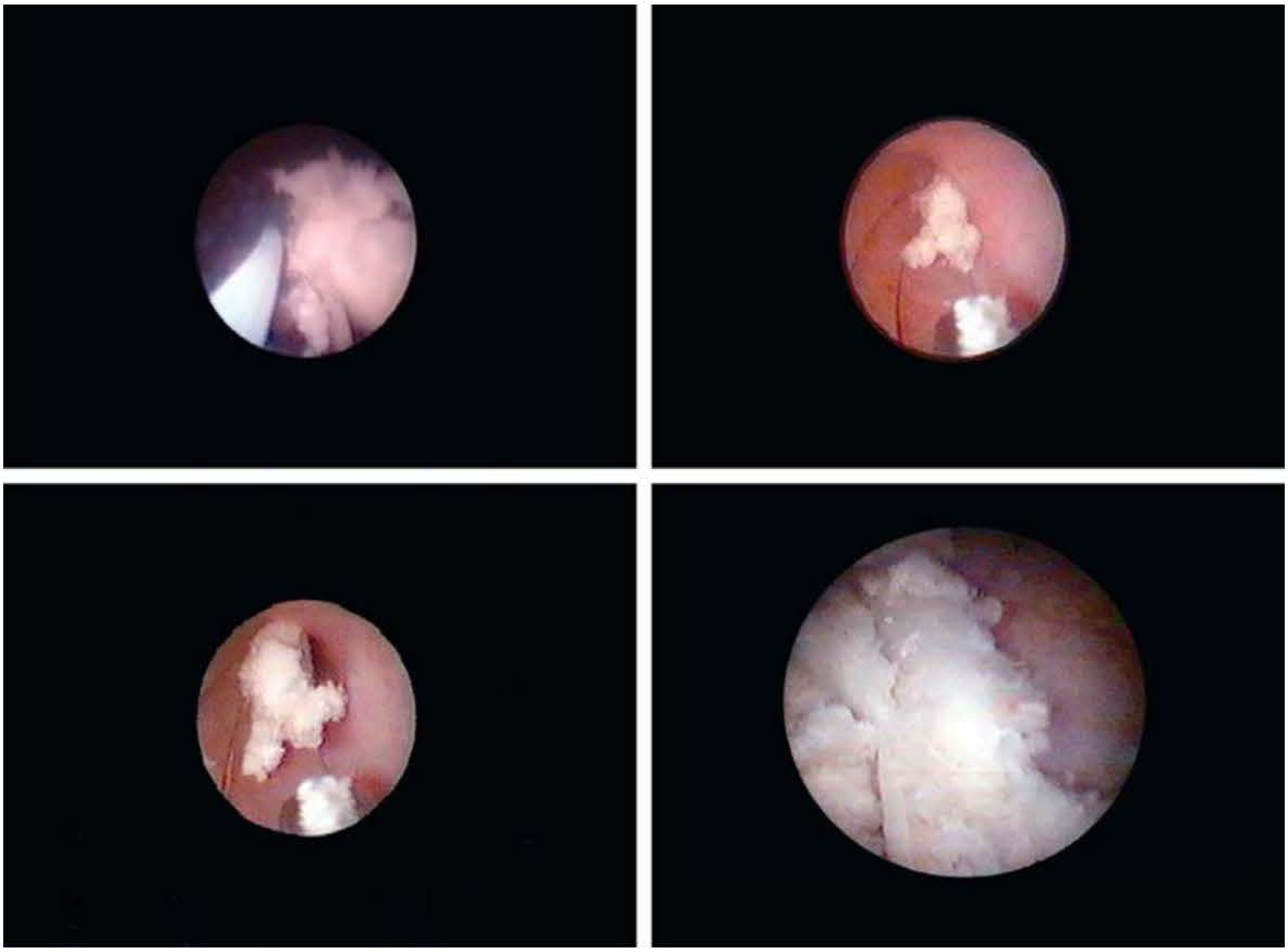


Figure 6.29 Extraction of a soft ureteral stone with the basket catheter.

In certain situations, the approach of pyelocaliceal calculi can be achieved with rigid and semirigid endoscopes (Figs 6.30 and 6.31). When the anatomy of the pyelocaliceal system does not allow for this type of approach, flexible endoscopes will be used.

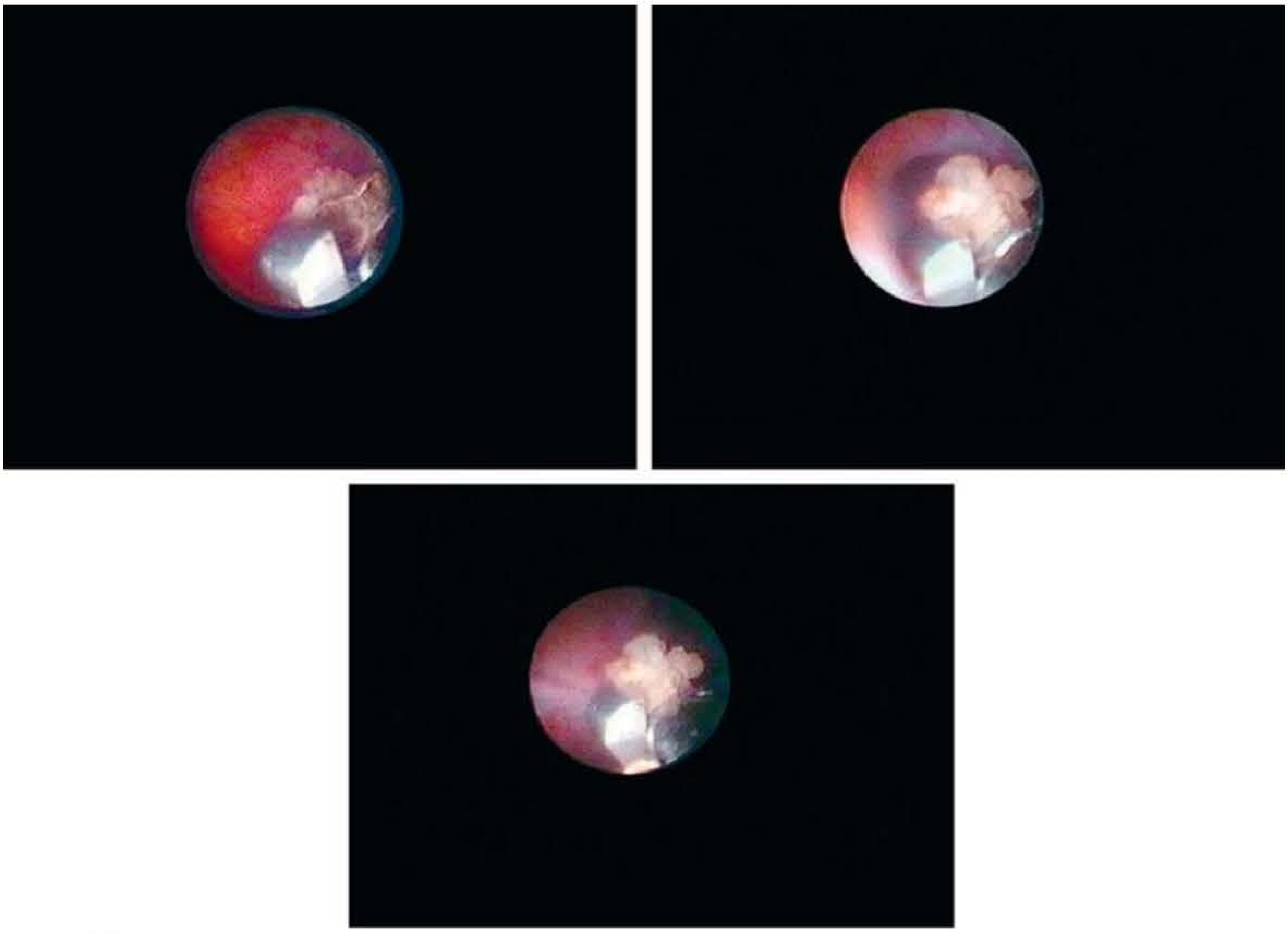


Figure 6.30 **Extraction of caliceal stones with a forceps during semirigid ureteroscopic approach.**

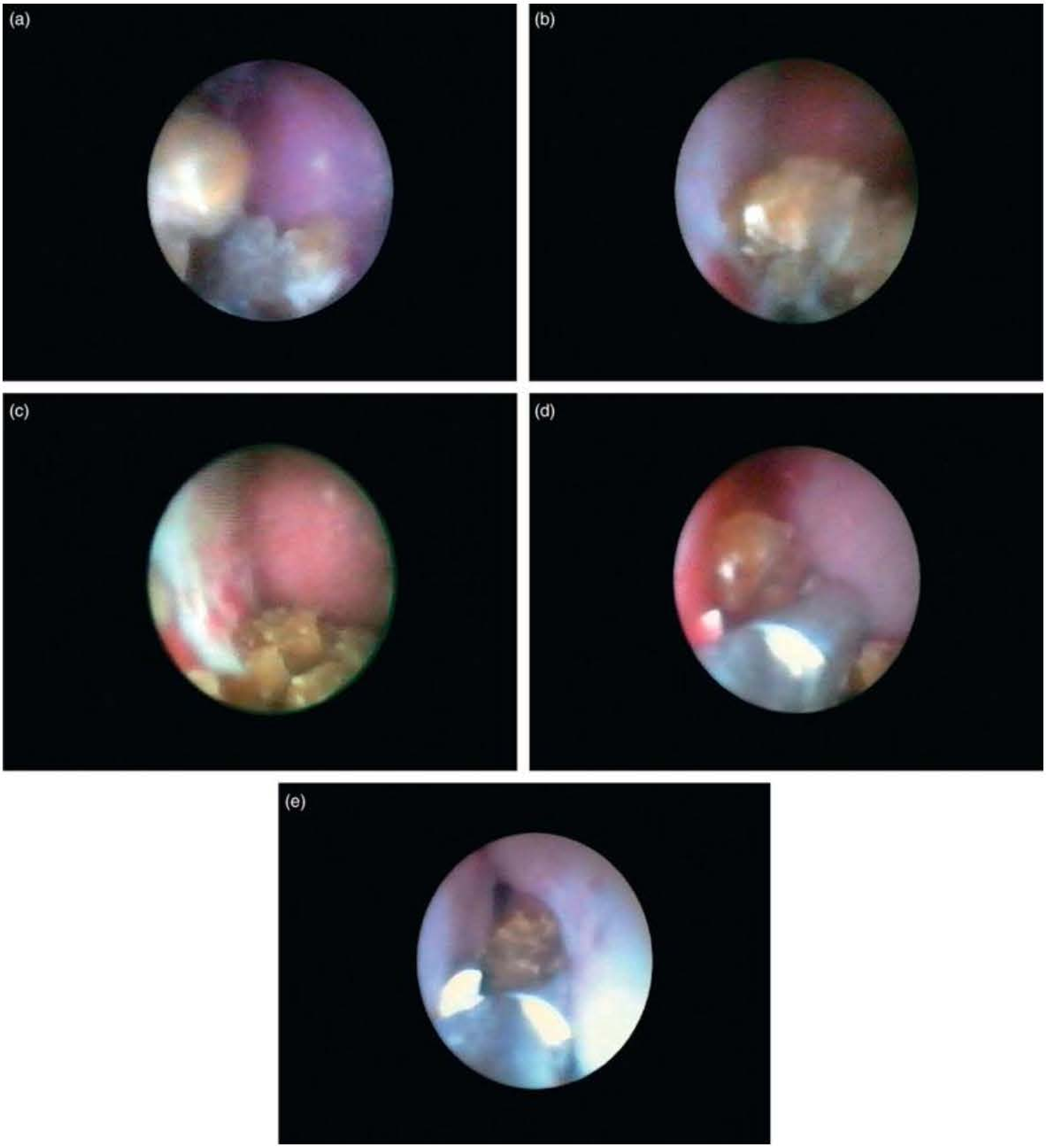


Figure 6.31 **Electrohydraulic lithotripsy of a caliceal stone under semirigid ureteroscopic control (a–c), followed by extraction of the resulting fragments with a forceps (d, e).**

6.3.7. Methods of Calculi Lithotripsy

The methods of intracorporeal lithotripsy include ultrasonic, electrohydraulic, ballistic, or laser lithotripsy (Table 6.1).

Table 6.1

Types of Contact Lithotripsy

Principle	**Mechanism**	**Probe**	**Advantages**	**Disadvantages**
Ultrasonic	Ultrasound generator that produces sinusoidal vibrations (20–27 kHz)	Rigid	Cheap, efficient (especially for softer calculi); allows concomitant suction of fragments; reduces the duration of the surgical	Reduced efficiency for ureteral calculi; the probe can frequently block; cannot be used with flexible instruments

			intervention in case of large calculi	
Electrohydraulic	Generates an electric arch at the probe's tip, producing shock waves close to the stone	Flexible	Cheap, efficient; allows fragmentation of stones with a medium roughness; flexible probe	May produce lesions of the soft tissues; ascendent migration of the fragments; inefficient for rough calculi
Pneumatic	Compressed air that triggers the probe	Rigid	Cheap and efficient; allows the destruction of any type of stone	Rigid probes; may determine the stone's propulsion
Ho:YAG laser	Photothermal effect	Flexible	Very efficient, can fragment any type of stone; may be used with flexible instruments; allows retrograde lithotripsy of renal calculi	Very expensive; fragmentation of the calculi may take more time

6.3.7.1. Ballistic Lithotripsy

The success rates of ballistic lithotripsy vary in different studies between 73% and 96%, an efficacy similar to that of electrohydraulic lithotripsy (Knispel et al., 1998; Menezes et al., 2000). The arching of the probe during lithotripsy determines a significant reduction of the impact force (Zhu et al., 2000).

The relatively nontraumatic nature of ballistic lithotripsy (Geavlete et al., 1997) allows the avoidance of placing a ureteral stent at the end of the procedure. Kok et al. (1998) reported the use of a ureteral stent in only nine patients in a group of 68 who underwent ballistic lithotripsy.

As in the case of other fragmentation methods, the ballistic lithotripter must be activated only in case of a correct visualization of the stone and of the probe's position (Fig. 6.32). The stone's fixation, which is relatively easy in case of a renal or vesical localization, may be difficult in case of ureteral stones. Sometimes, the stone's fixation between the spirals of a basket catheter or occlusion of the proximal ureter by one of the previously mentioned methods may be necessary.

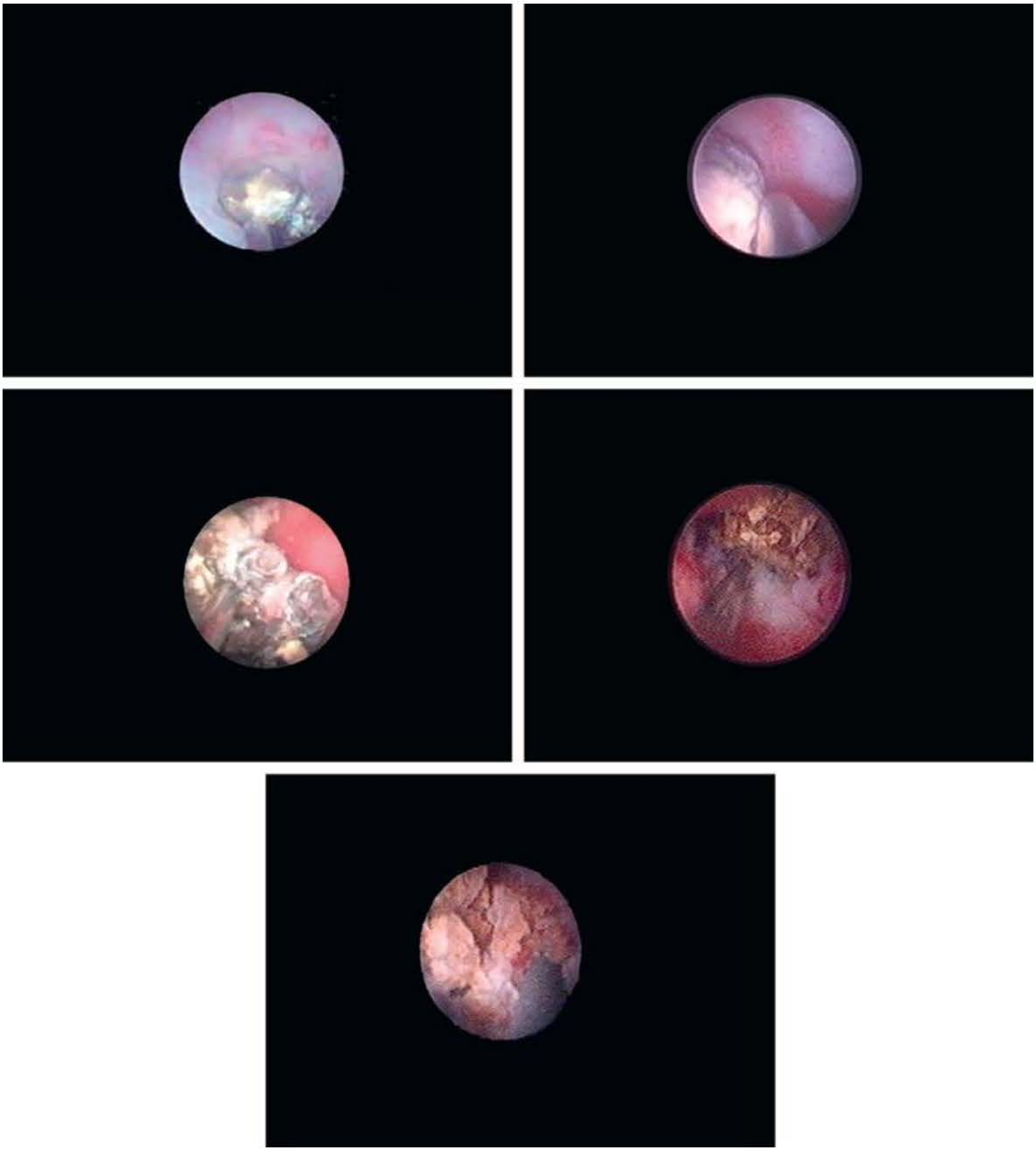


Figure 6.32 **Endoscopic aspects of ballistic lithotripsy for ureteral calculi.**

6.3.7.2. Ultrasonic Lithotripsy

Ultrasonic lithotripsy is based on the stone's fragmentation by the energy provided by the high-frequency vibration of a rigid metallic transducer. This type of lithotripsy requires performing a ureteral dilation in order to allow the use of rigid ureteroscopes. For fragmentation, the tip of the metallic transducer must be in direct contact with the stone. Its dissolution should be started from the periphery, avoiding its perforation. The resultants small fragments must be suctioned or extracted with adequate clamps.

For an efficient dissolution, the stone must be positioned between a probe's spirals and maintained in a fixed position in order to avoid the recoil.

The possibility for the ultrasonic destruction of calculi differs according to their chemical composition, dimensions, density, and roughness. Smaller calculi are fragmented more quickly. Also, the destruction of calculi with a smooth surface is more difficult than for rough stones (Marberger, 1983; Segura and LeRoy, 1984).

Chaussy et al. (1987) reported a rate of complete fragmentation of 96.6% in a group of 118 patients using 2.5 F probes, which can be advanced through small-caliber ureteroscopes. Similar results were reported by Fuchs (1988).

In another study, Murthy et al. (1997) compared the results obtained by ultrasonic lithotripsy with 3 F probes in a group of 25 patients with those provided by ballistic lithotripsy in a group of 122 patients. The success rate was significantly higher in the case of ballistic lithotripsy (97.3% vs. 84%).

6.3.7.3. Electrohydraulic Lithotripsy

Electrohydraulic lithotripsy of ureteral calculi requires the use of a probe with dimensions varying between 1.6 F and 1.9 F (Fig. 6.33). This is introduced through the working channel of the rigid or flexible ureteroscope, its end being placed 2–5 mm from the end of the ureteroscope in order to protect the optical system during the electric discharges. The probe is advanced until it is close to the stone, but not in direct contact with it, the maximum efficiency of the waves being obtained when the distance between its end and the stone is of approximately 1 mm (Zhong et al., 1997). In order to reduce the risk of ureteral lesions, single impulses with low intensity (50–60 V) are initially generated. The intensity can subsequently be increased, according to the stone's resistance.

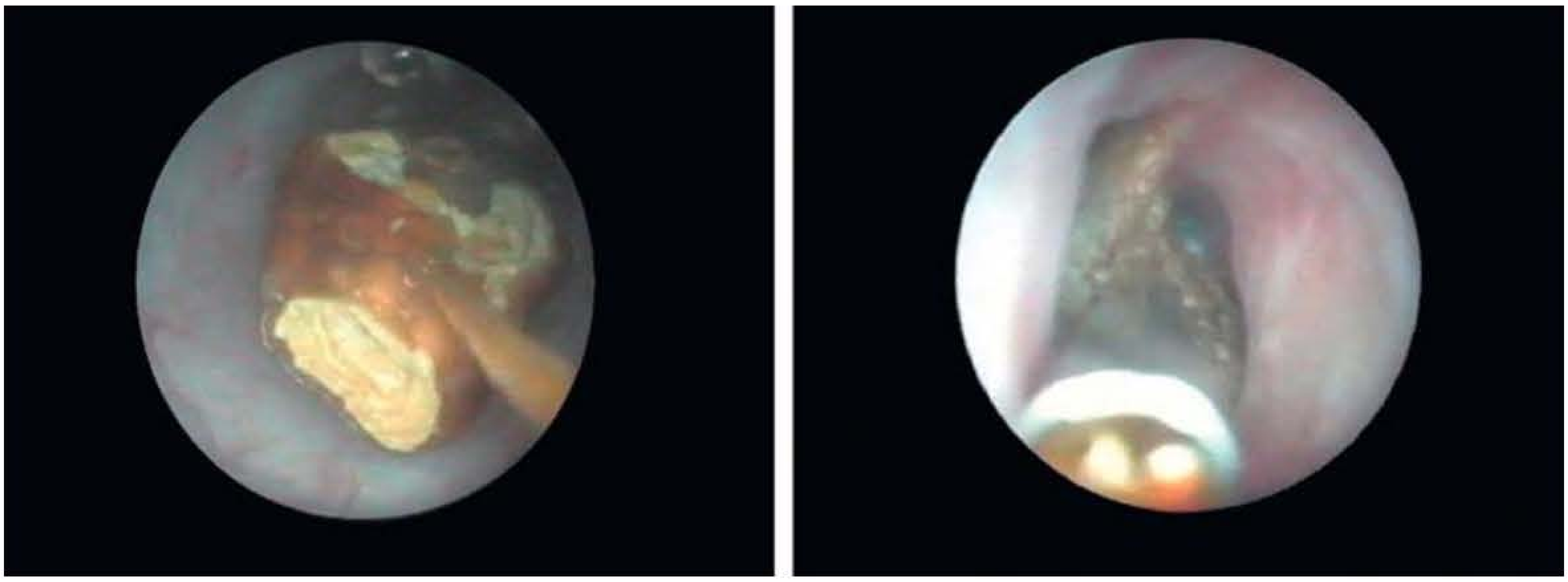


Figure 6.33 **Electrohydraulic lithotripsy of ureteral calculi.**

However, it is recommended to limit the maximum energy level used in order to minimize the risk of perforation (Denstedt and Clayman, 1990). The insulation of the distal end loosens after 50–60 s from the generation, requiring the probe to be replaced (Segura, 1999).

The resulting fragments can be extracted with a clamp or with a basket catheter (Figs 6.34 and 6.35). It is not recommended to attempt fragmenting the stone into particles smaller than 2 mm due to the increased risk of ureteral wall injury.

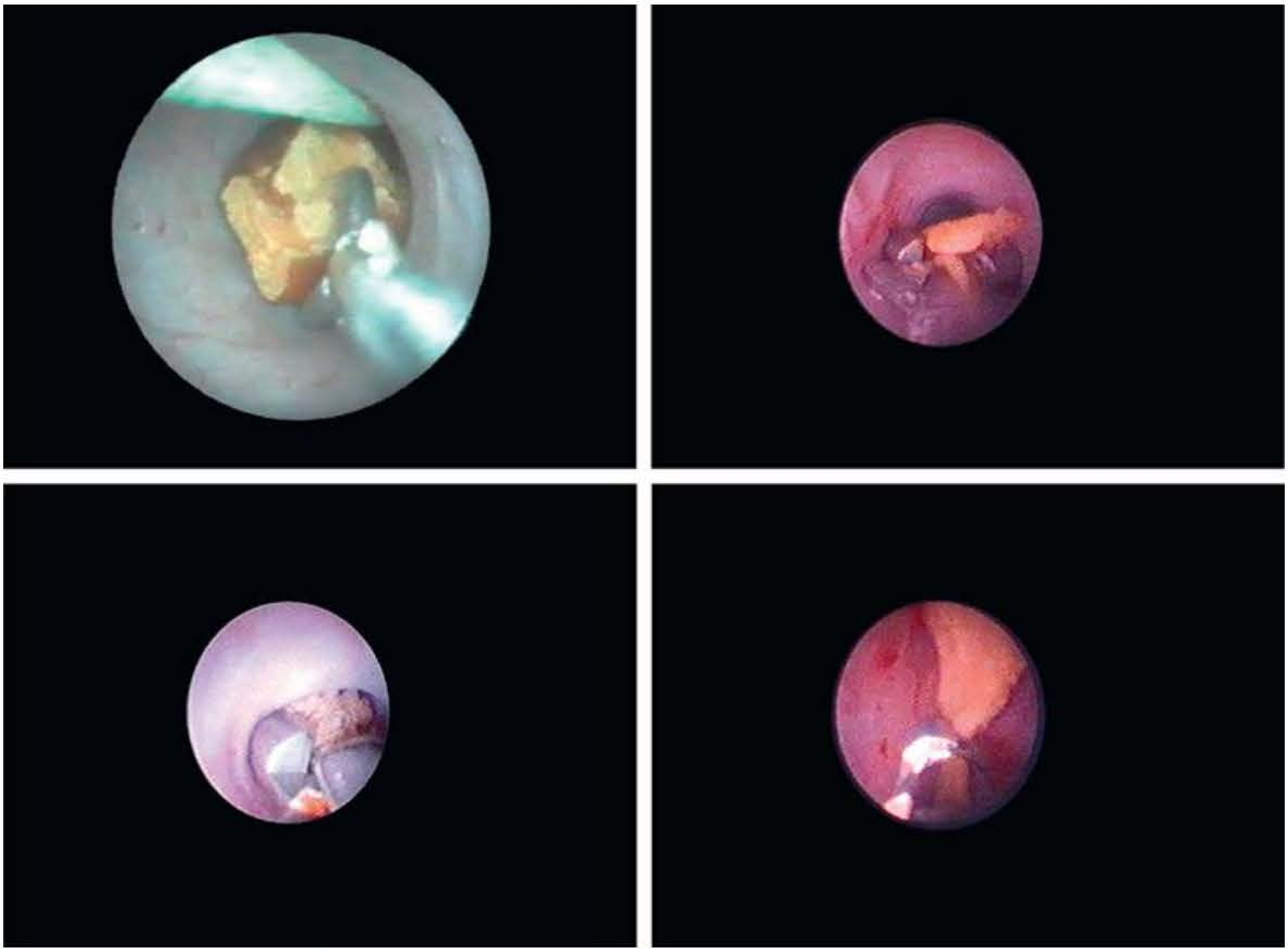


Figure 6.34 **Extraction of lithiasic fragments with a clamp.**

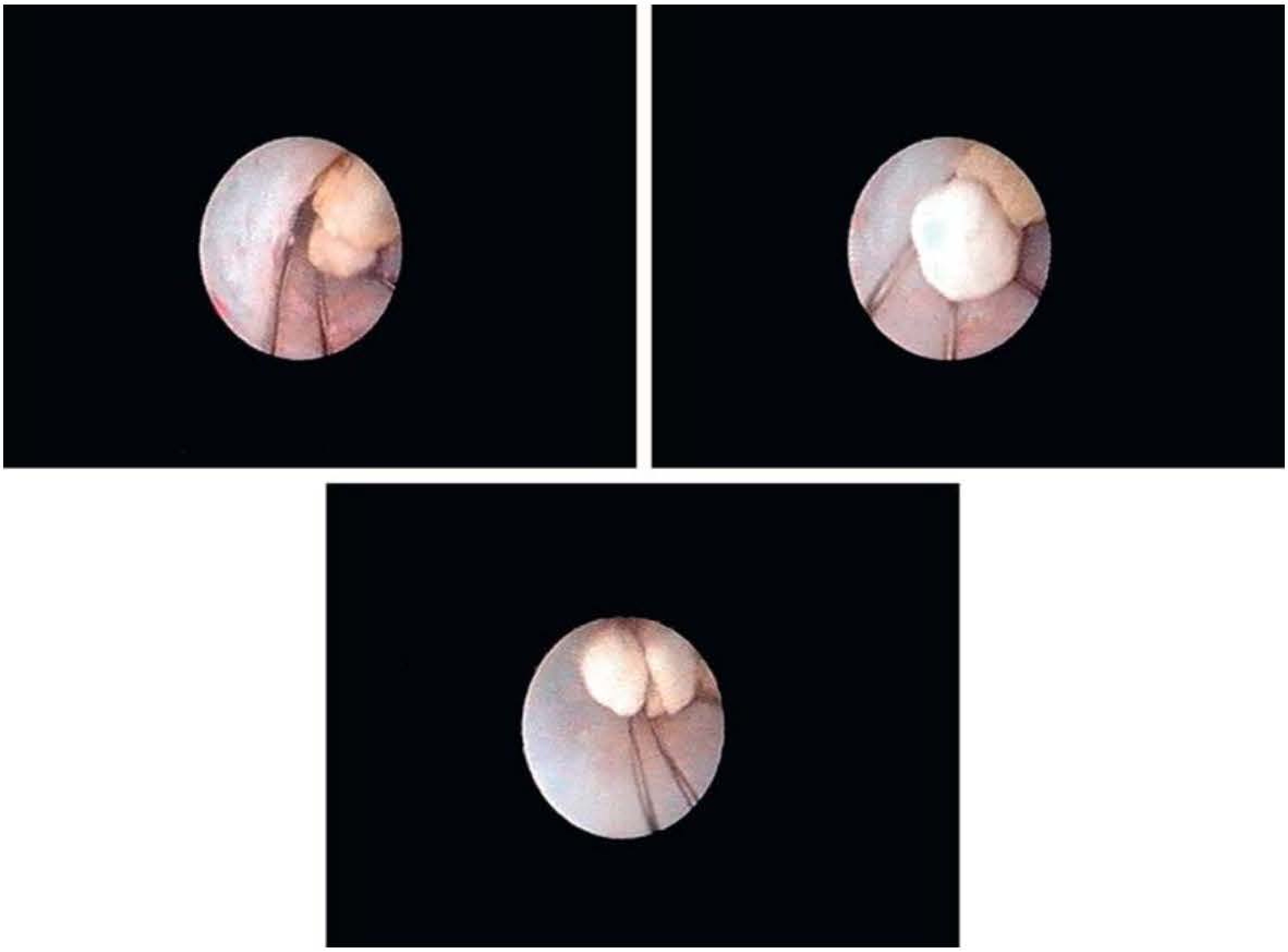


Figure 6.35 **Extraction of lithiasic fragments using a basket catheter.**

The success rate of stone fragmentation is of approximately 90%. The success rate also depends on the composition, dimensions, and surface of the lithiasic fragments (Basar et al., 1997). The stone-free rate decreases with the increase of the stone's dimensions, being significantly lower than that obtained through Ho:YAG lithotripsy (Teichman et al., 1997).

6.3.7.4. Laser Lithotripsy

The advances regarding laser lithotripsy are due to the introduction of the Ho:YAG laser, with a wavelength of 2150 nm, released in a pulsed manner through quartz fibers. The safety and efficacy of Ho:YAG have been underlined by many studies. Sofer detected a complication rate of under 1% with an efficacy of 97–100% after a single procedure, without dilating the ureteral orifice or placing a ureteral stent after the ureteroscopy (Sofer et al., 2002).

Another study, conducted by Grasso and Bagley (Grasso et al., 1998), assessed the efficacy of treatment by retrograde ureteroscopy with Ho:YAG lithotripsy for proximal ureteral calculi with a diameter larger than 2 cm. The success rate after one procedure was 95%, only one patient requiring a second intervention. No significant intra- or postoperative complications were recorded.

The laser lithotripsy technique is relatively simple and implies placing the fiber in contact with the stone's surface before activation. Good visibility is essential for preventing ureteral perforation. After initiating laser lithotripsy, a short break is frequently necessary due to the "snowstorm" determined by the lithiasic fragments (Fig. 6.36) (Scarpa et al., 1999).

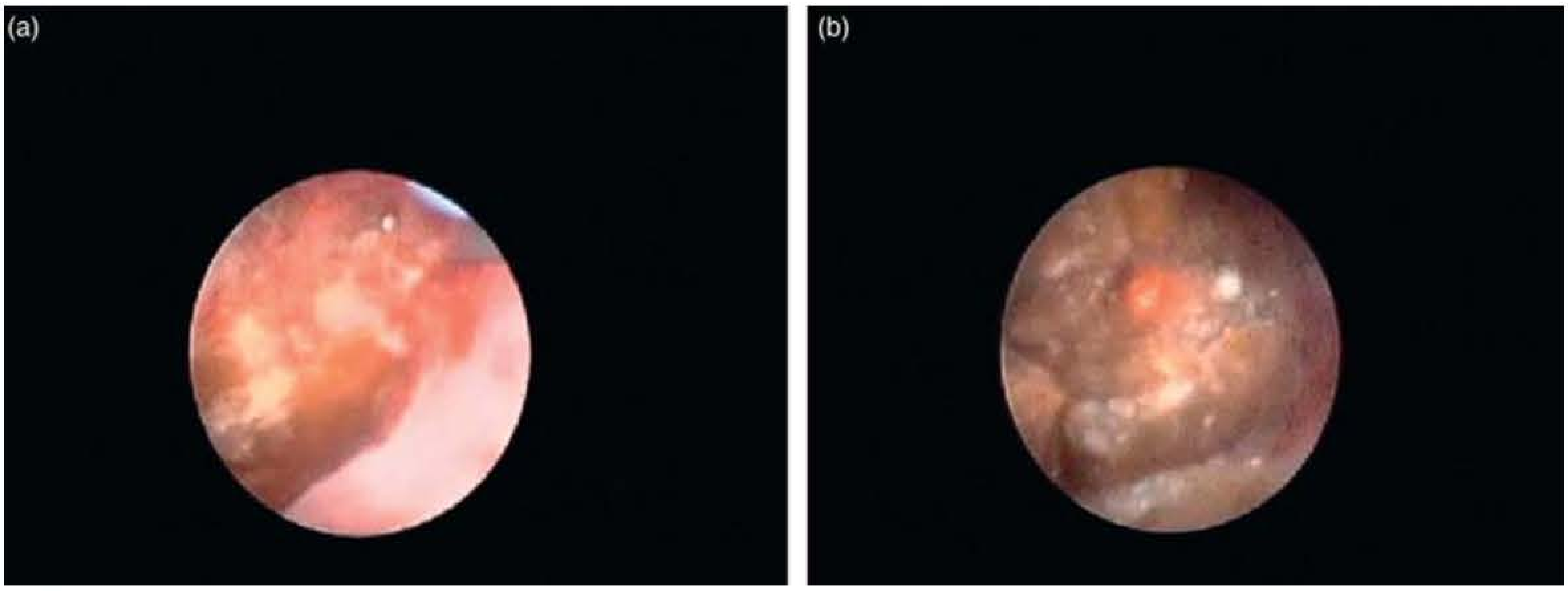


Figure 6.36 **The Ho:YAG laser lithotripsy technique: placing the fiber in contact with the stone (a), lithotripsy of the stone (b).**

Due to the potential of this type of laser for sectioning metal, it is necessary to avoid the discharge of the fiber in the immediate vicinity of the accessory instruments (Fig. 6.37), especially of the fine ones made of nitinol (Honeck et al., 2006; Freiha et al., 1997).

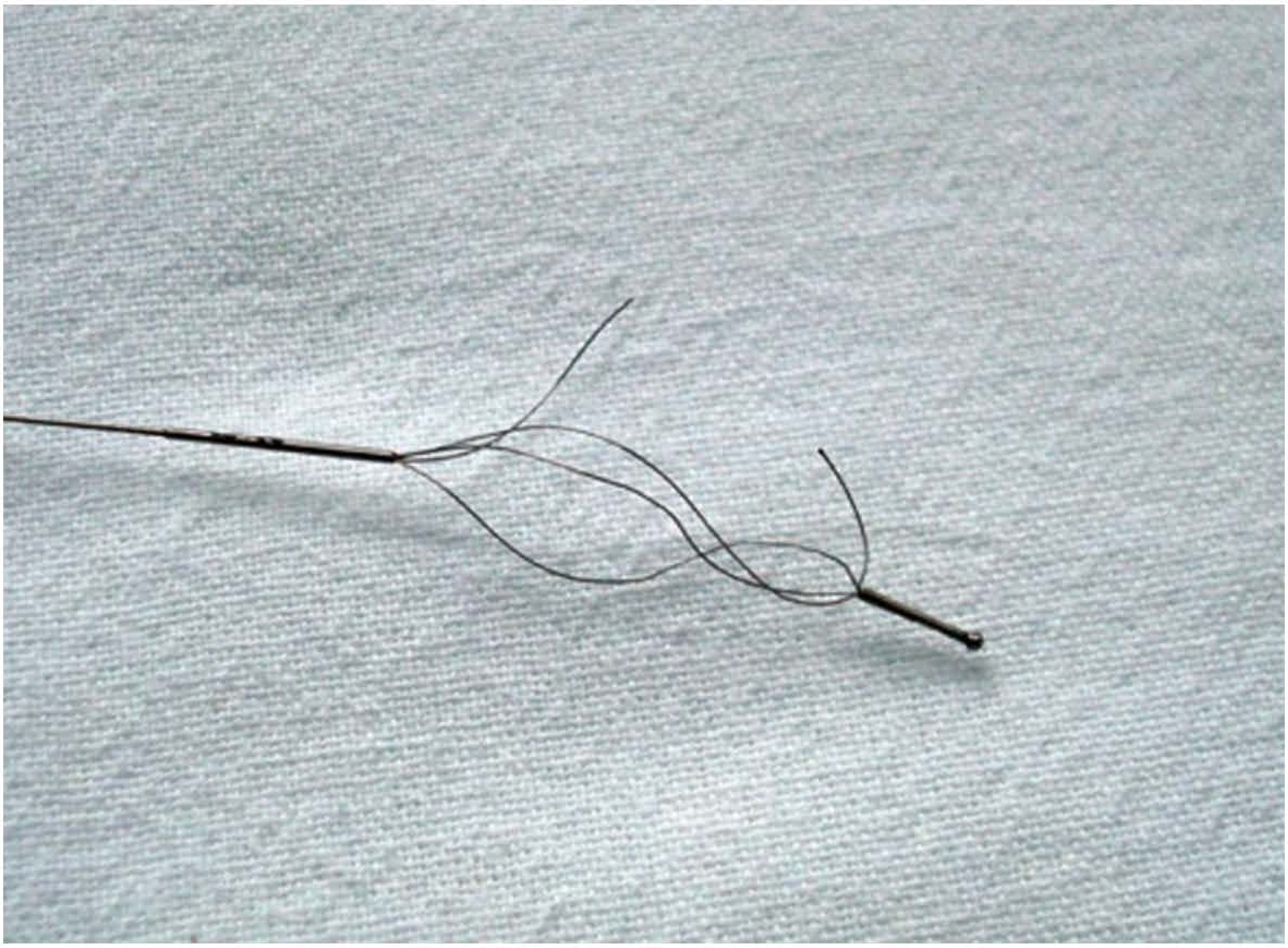


Figure 6.37 **Basket catheter deteriorated during laser lithotripsy.**

In particular situations (e.g., fixed basket catheters with stones inside), this problem becomes a potential advantage: one of the basket's spirals will be sectioned by laser, allowing the disengagement and extraction of the catheter.

The tip of the probe should be placed at least 2 mm from the endoscope's end, in order to prevent the destruction of the optical system or of the working channel; 200 and 365 μm fibers can be used for flexible intracorporeal lithotripsy. Ho:YAG laser lithotripsy depends on the pulsed energy generated and on the fiber's diameter. Thus, its efficacy is correlated with the energy's density, which increases with the decrease of the fibers' diameter (Vassar et al., 1998). The energy necessary for the fragmentation of the stones is lower than that used for other therapeutic laser applications. A power of 0.6–1.2 J is generally used, with a frequency of 5–15 Hz (Wollin and Denstedt, 1998; Spore et al., 1999). Due to the risk of the stone's propulsion and of the fiber's destruction, it is recommended to begin the procedure with a reduced energy of 0.6 J and with a frequency of 6 Hz, which will subsequently be increased as needed (Spore et al., 1999). Lithotripsy is performed by moving the laser beam over the stone's surface in order to avoid the generation of large fragments. The laser beam must be kept at least 1 mm from the ureteral wall (Fig. 6.38).

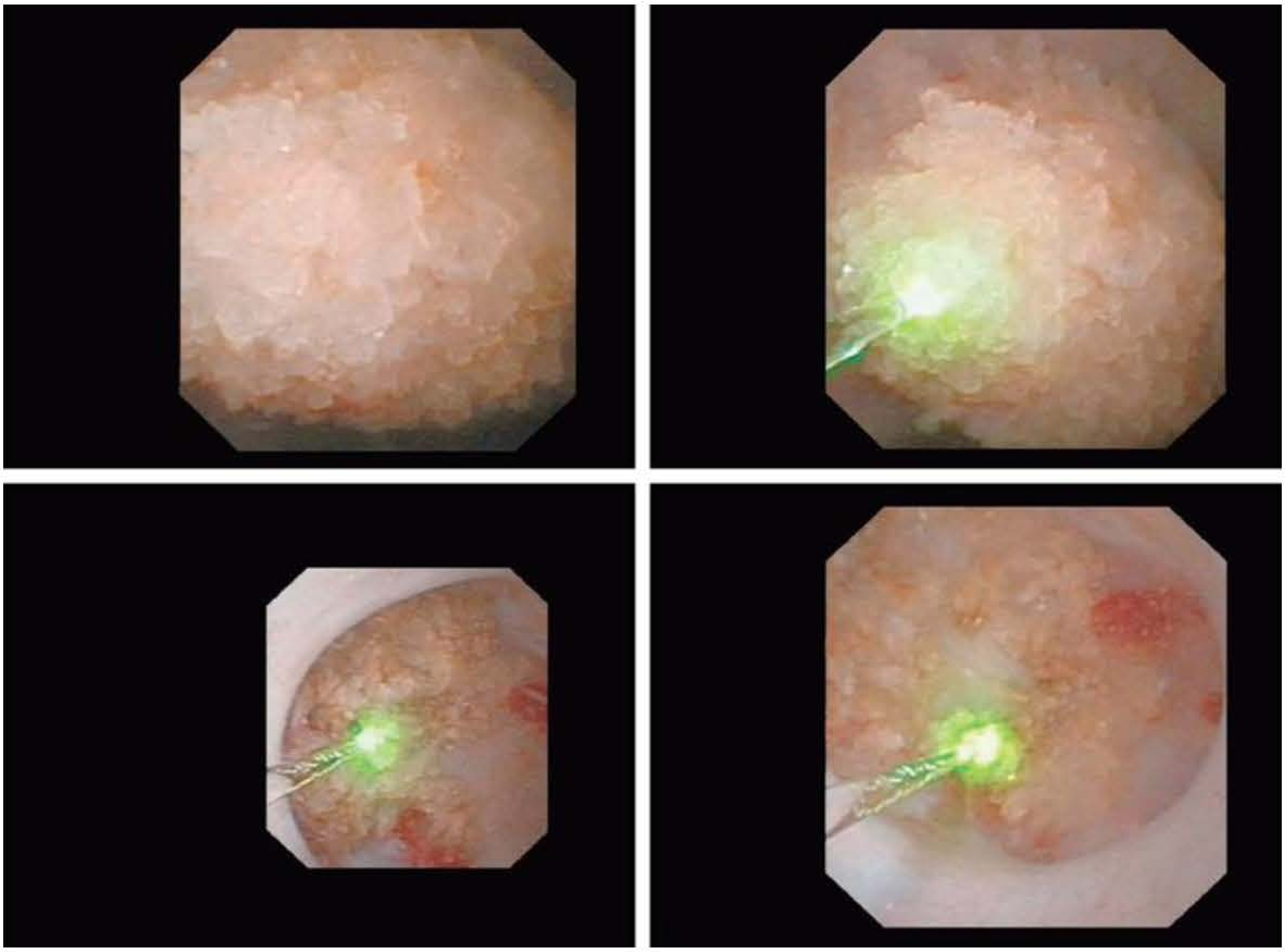


Figure 6.38 **Ho:YAG laser lithotripsy into 1–2 mm fragments.**

6.3.8. Ureteral Stenting

Classically, ureteral stenting (Fig. 6.39) has been routinely recommended at the end of the procedure in all patients who undergo ureteroscopy for ureteral calculi.

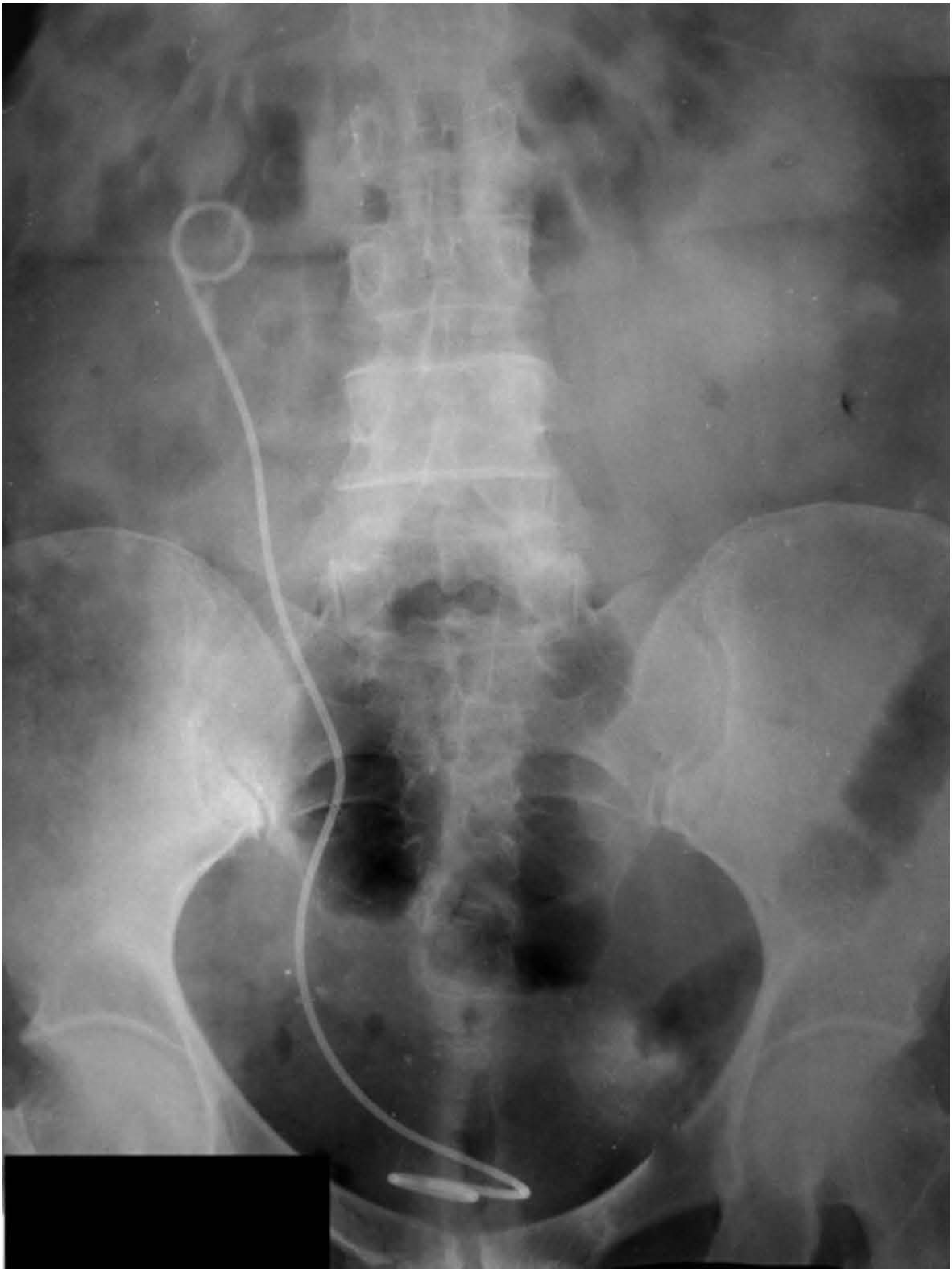


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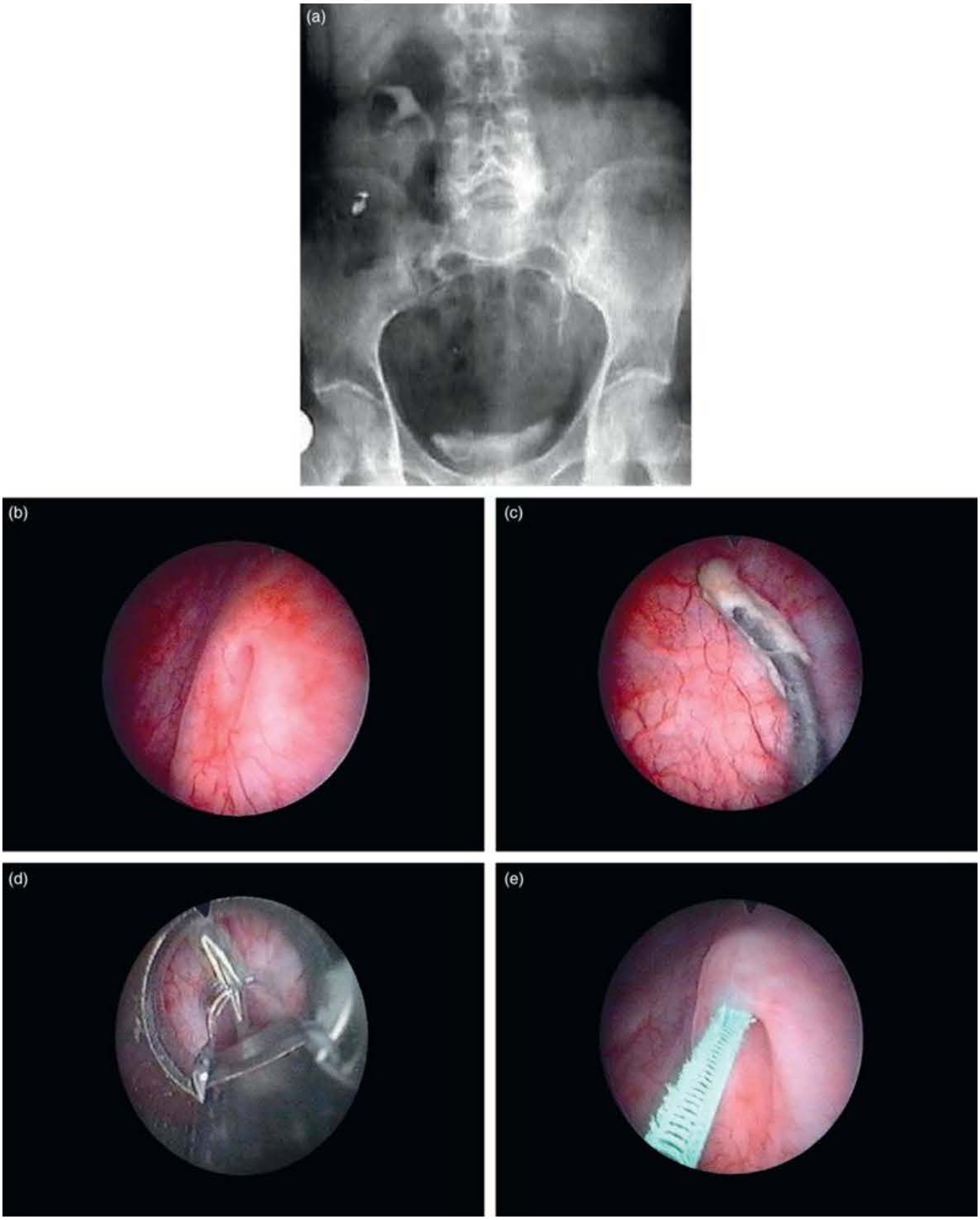
Figure 6.39 **Correctly positioned JJ stent at the end of the ureteroscopy.**

Nevertheless, numerous recent studies have re-evaluated the utility and indications of this maneuver (Georgescu et al., 2007a).

There are many theoretical advantages of placing a JJ stent. This allows the elimination of the obstruction that may occur as a result of ureteral edema, protecting the renal function and improving its symptomatology. Also, stenting facilitates the elimination of remaining lithiasic fragments, contributes to the healing of ureteral lesions, and prevents the occurrence of secondary stenoses.

On the other hand, placing of the ureteral stent determines the occurrence of a specific morbidity (Geavlete and Georgescu, 1998; Geavlete et al., 2000b, 2004; Georgescu et al., 2007b). The potential complications include fracture (Fig. 6.40) or migration of the stent (Figs 6.41 and 6.42), ureteral erosion, and encrustation.



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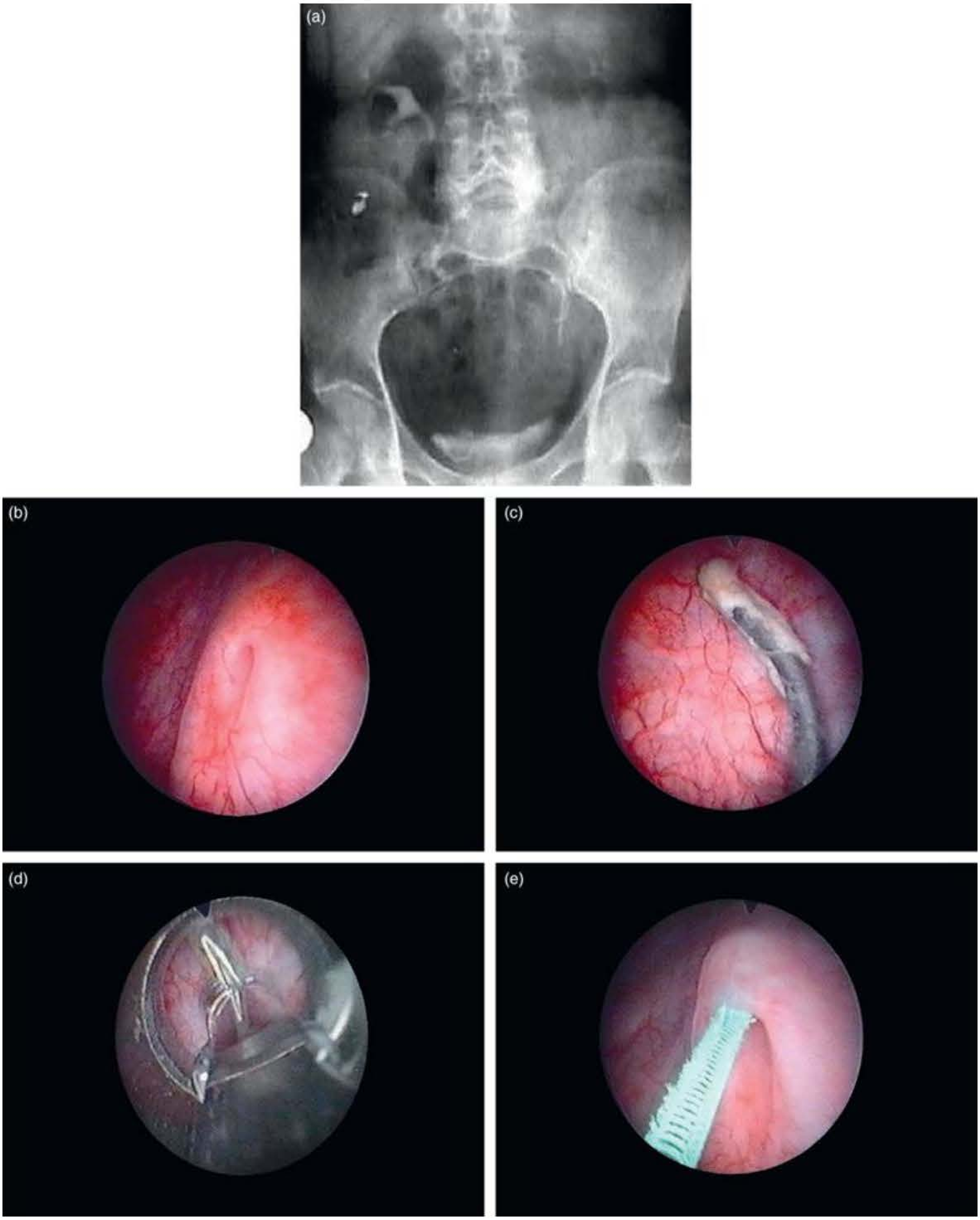


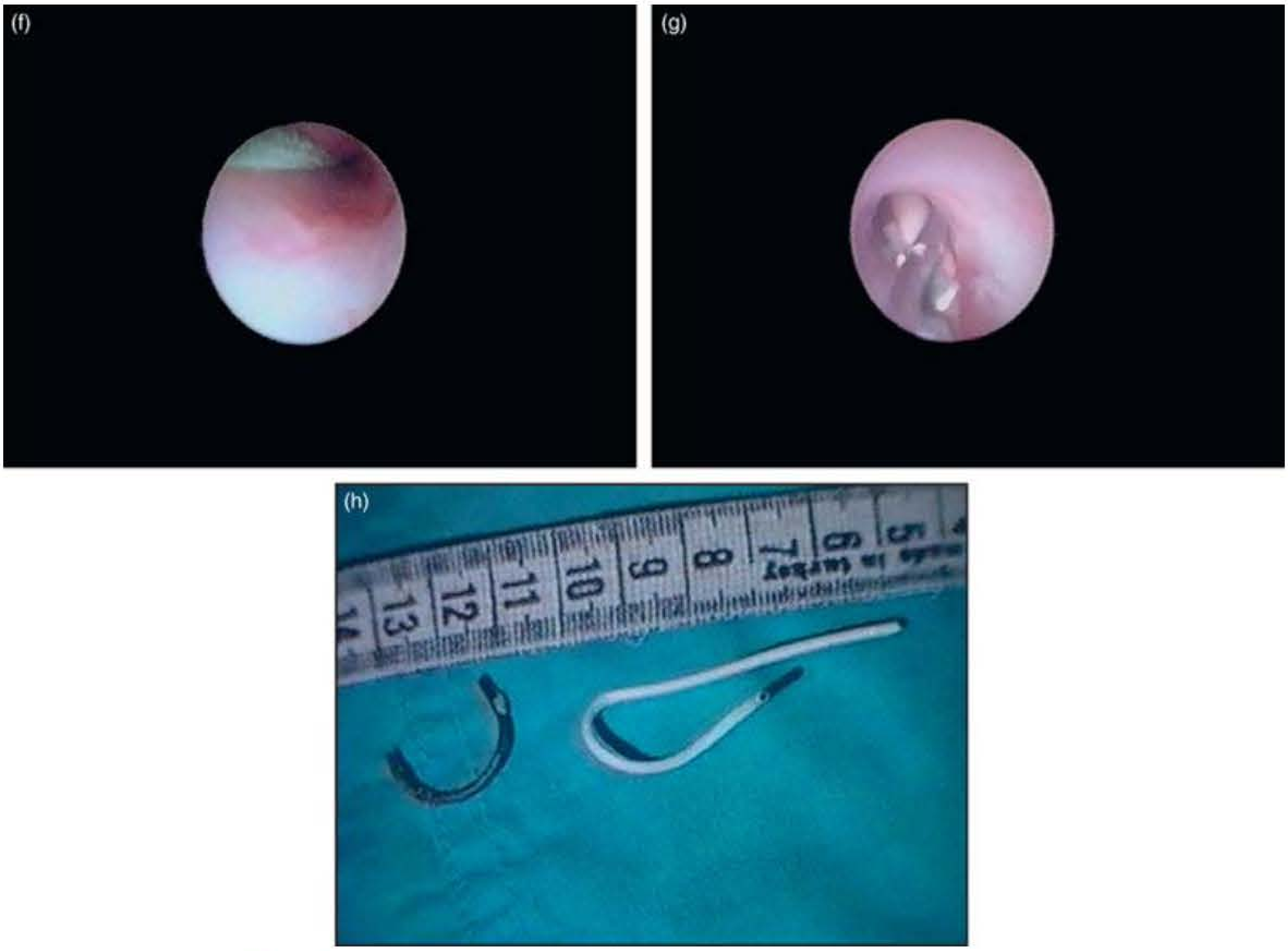


Figure 6.40 **The ureteroscopic management of a fractured left JJ stent.**

Radiological aspect of the stent (a), the free left ureteral orifice (b), the distal fragment of the stent in the urinary bladder (c) extracted with a clamp (d), insertion of the guidewire into the left ureteral orifice (e), followed by extraction of the proximal part of the stent (f, g), the two fragments after extraction (h).

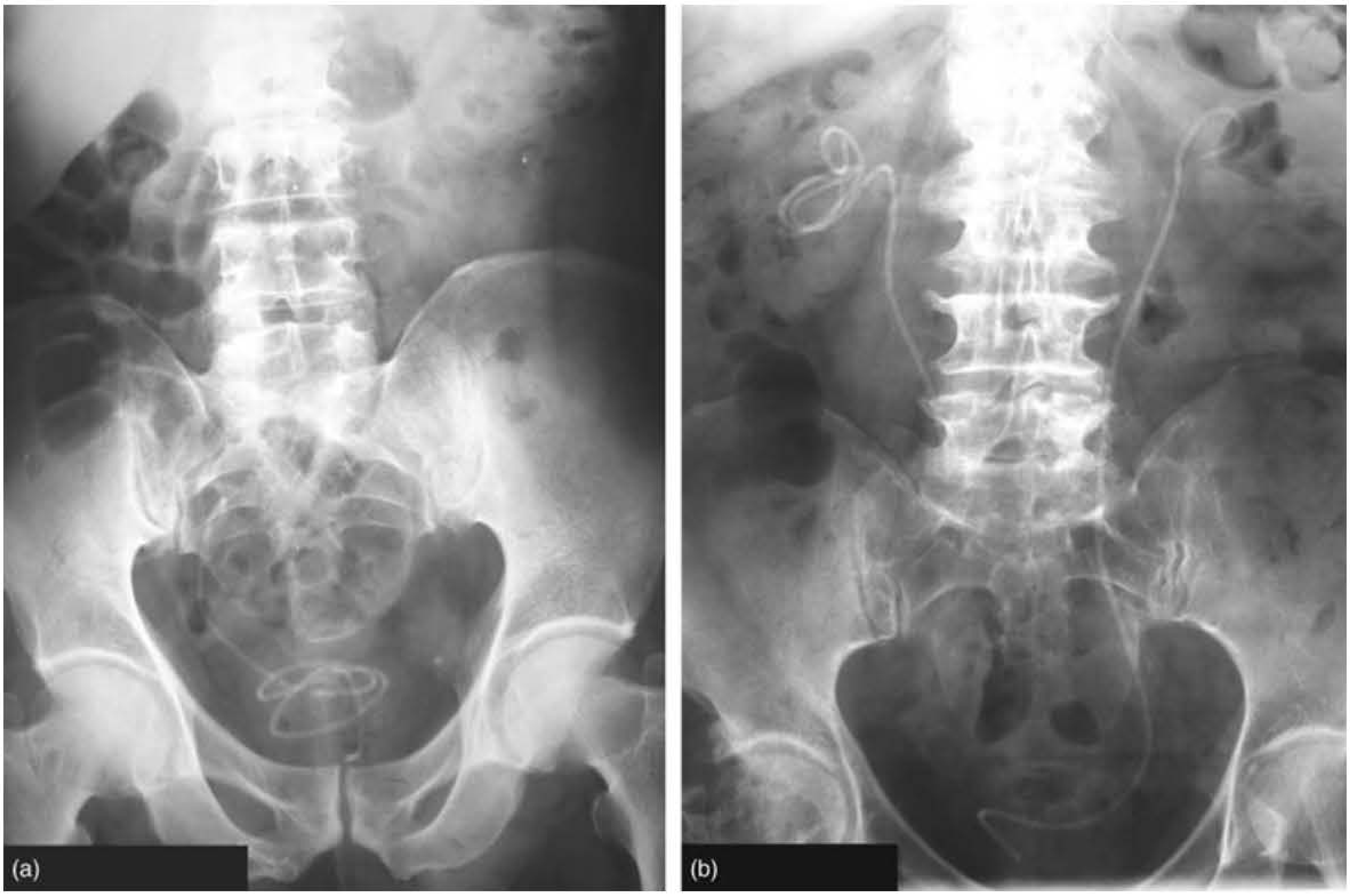


Figure 6.41 JJ stent migrated downward (a) and upward (b).

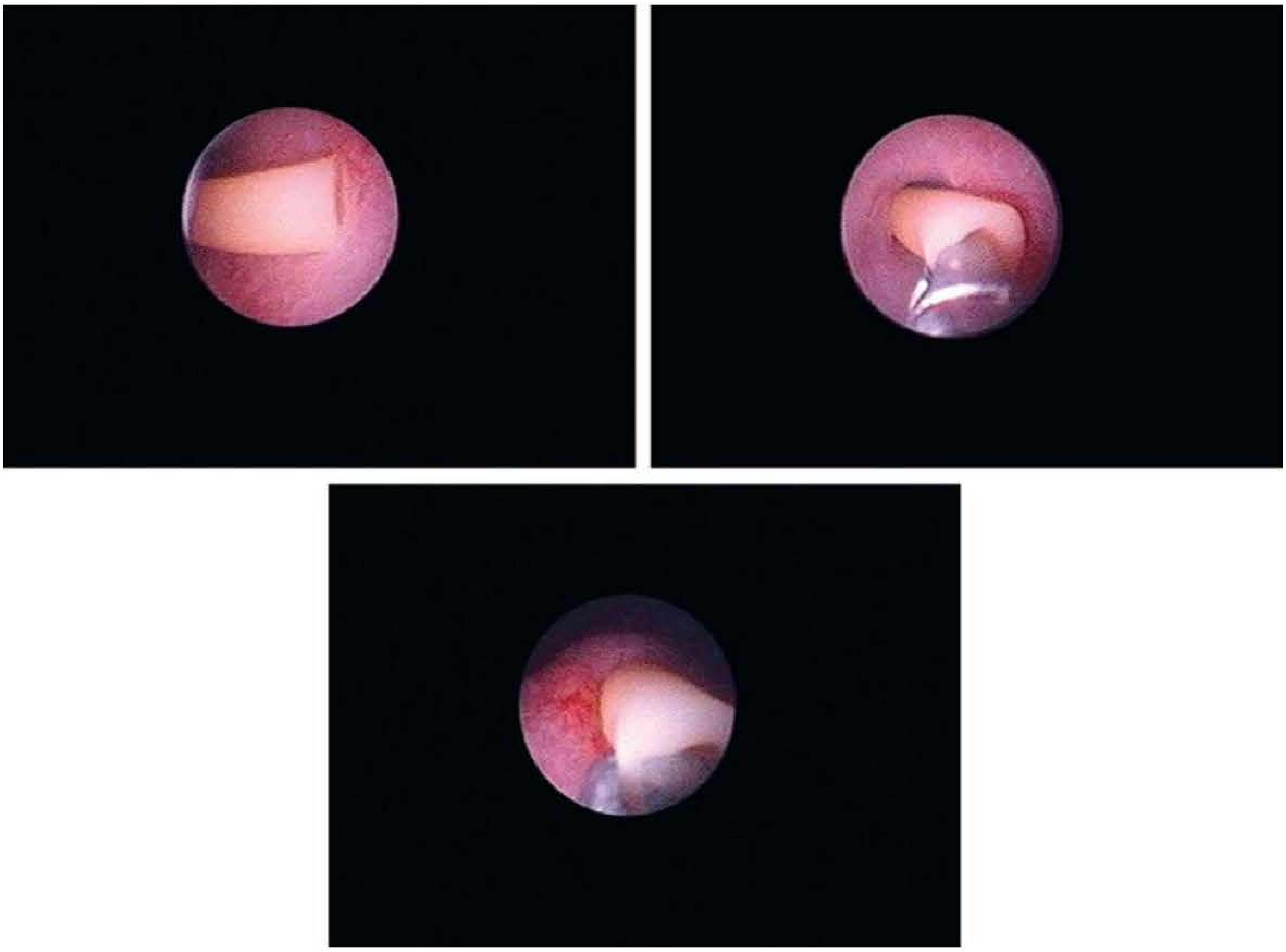
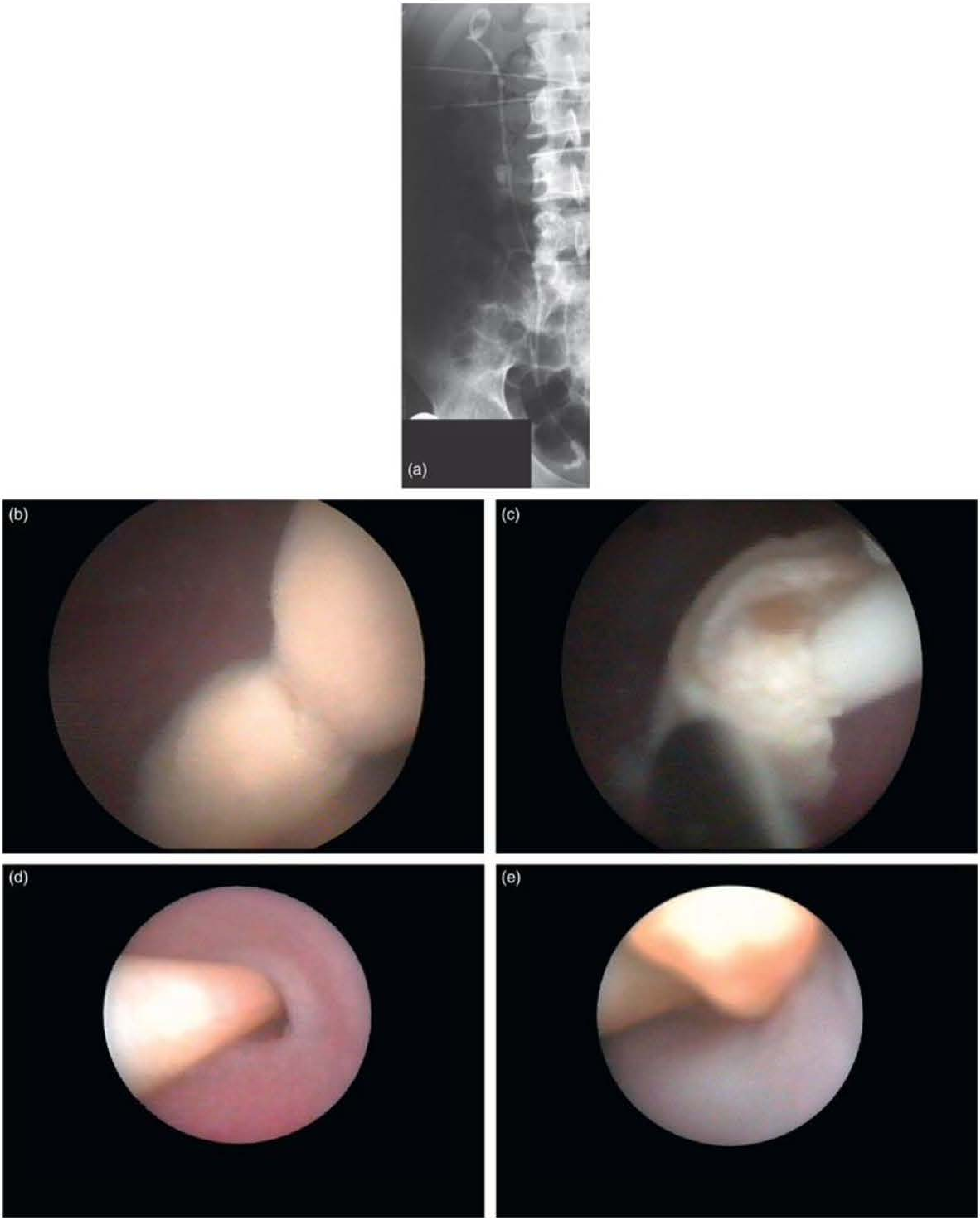


Figure 6.42 Endoscopic extraction of a JJ stent with ascendent migration.

The incidence of stent encrustation is approximately 15% after 3–4 weeks, reaches 76% after more than 12 weeks (Lupu et al., 1986; El-Faqih et al., 1991), and can raise a series of therapeutic issues, in some cases requiring combined endoscopic approach (Fig. 6.43) (Geavlete et al., 2007a).



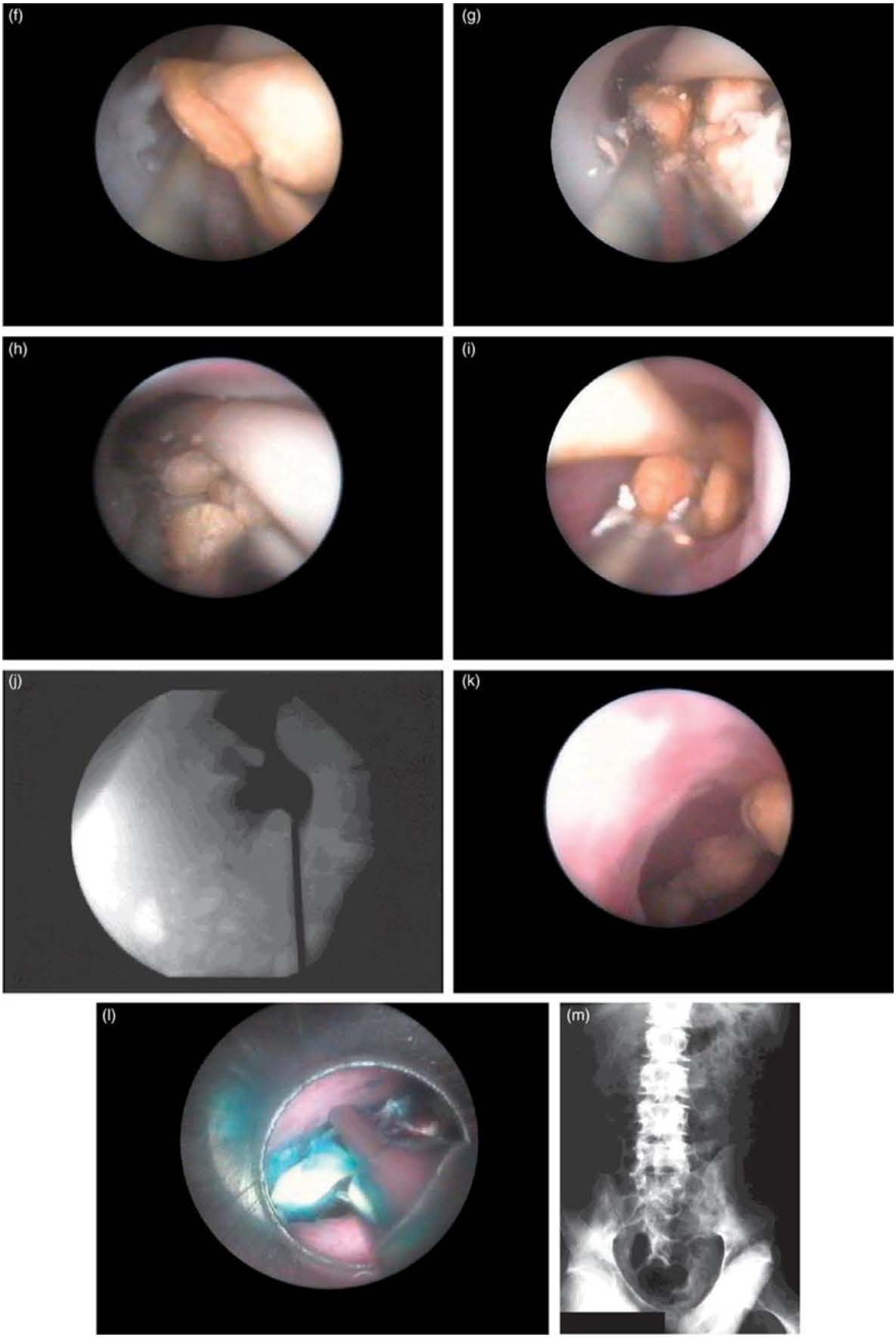


Figure 6.43 **Combined endoscopic approach of a calcified left JJ stent along its entire length.**
Radiological aspect of the stent (a), ballistic lithotripsy of the calcifications from the vesical volute (b, c), insertion

of the ureteroscope beside the stent (d), ballistic lithotripsy of the ureteral calcifications (e–h), followed by the extraction of the lithiasic fragments with a forceps (i), calcifications of the pyelic part of the stent (j, k), percutaneous extraction of the renal calcifications and of the JJ stent (l), stone-free radiological aspect at the end of the intervention (m).

Ureteral stenting is also associated with irritative symptoms of the lower urinary tract, lumbar pains, and urinary infections. Over 90% of patients present micturition disturbances determined by the presence of the stent (Pollard and Macfarlane, 1988). Hematuria is a frequent manifestation determined by the presence of the stent (Chen et al., 2002).

Regarding the patients' comfort, Chen et al. (2002) did not observe any significant differences regarding postoperative pain between those in whom ureteral stenting was performed and those in whom a JJ stent was not placed. However, the incidence of irritative vesical symptoms is significantly higher (83.3% vs. 13.3%) in patients in whom a ureteral stent was placed after the intervention.

The studies conducted by Denstedt and by Borboroglu, respectively, also demonstrated an increased incidence of lumbar and abdominal pains, of dysuria and pollakiuria in patients in whom an autostatic ureteral catheter was placed after the intervention (Denstedt et al., 2001; Borboroglu et al., 2001).

Byrne observed that bladder irritative symptoms and lumbar pains are more intense in the first days after the intervention in patients without a ureteral stent, the ratio reversing after the sixth day from the ureteroscopic approach (Byrne et al., 2002).

Regarding the necessity for postprocedural antialgic treatment, the studies performed have shown that it is not influenced by placing a ureteral stent (Hosking et al., 1999; Rane et al., 2000; Denstedt et al., 2001). Also, routine ureteral stenting determines an increased incidence of transient vesicoureteral reflux.

One of the important arguments in favor of ureteral stenting at the end of the ureteroscopy is represented by the increase in the stone-free rate. However, Denstedt observed a stone-free rate of 100% in patients who underwent laser lithotripsy of the stones into fragments smaller than 3 mm, without placing a ureteral stent. Other studies have also demonstrated that after the lithotripsy of stones into small enough fragments, which do not require extraction with a forceps or a basket catheter, there are no significant differences between the stone-free rates with or without ureteral stenting (Borboroglu et al., 2001; Netto et al., 2001; Chen et al., 2002).

Some authors have suggested that placing an autostatic ureteral catheter after ureteroscopy determines a decrease in the incidence of postoperative stenoses (Harmon et al., 1997; Netto et al., 1997). Nevertheless, the studies that have been conducted have not demonstrated a statistically significant difference between the rates of this complication according to whether or not a JJ stent was placed after the uncomplicated ureterosopic approach (Denstedt et al., 2001; Chen et al., 2002).

Another argument in favor of ureteral stenting is the reduction of the readmission rate due to postoperative complications, first of all due to pain that cannot be controlled by oral medication (Damiano et al., 2004). The results of different studies have demonstrated that the readmission rates in patients without ureteral stenting is approximately three times higher, however, without presenting significant values (4.3%) (Denstedt et al., 2001; Borboroglu et al., 2001; Byrne et al., 2002; Chen et al., 2002).

The assessment of the impact of ureteral stenting on the duration of the surgical intervention has led to contradictory results. Denstedt et al. (2001) did not observe significant differences for this parameter, the mean operating time being 36 versus 34 min. On the other hand, the studies conducted by Netto and after that by Byrne showed an increase by approximately 12 min of the intervention's duration as a result of placing the ureteral stent (Netto et al., 2001; Byrne et al., 2002).

Stenting determines a significant increase in the costs incurred by the ureteroscopic treatment of ureteral lithiasis, requiring additional maneuvers for extracting the stent.

In conclusion, recent data suggest that ureteral stenting is not necessary after uncomplicated ureteroscopic approach. However, there are specific situations that require placing an autostatic catheter. Absolute indications include the presence of renal insufficiency, patients with a single kidney, kidney transplantation, and ureteral wall injuries during the ureteroscopic procedure. Relative indications are represented by the presence of important ureteral edema (Figs 6.44 and 6.45), pregnancy, calculi larger than 2 cm, impacted ureteral calculi, and the presence in the immediate history of urinary infection or sepsis.

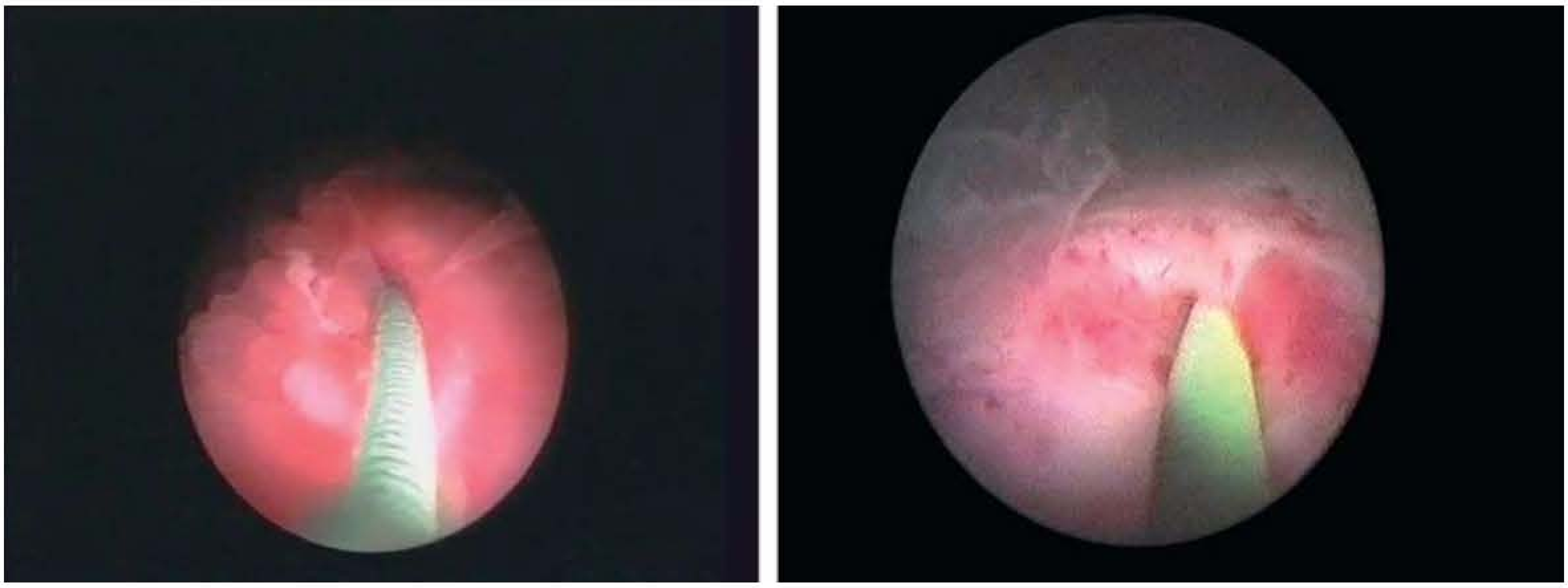


Figure 6.44 Edema of the ureteral orifice.

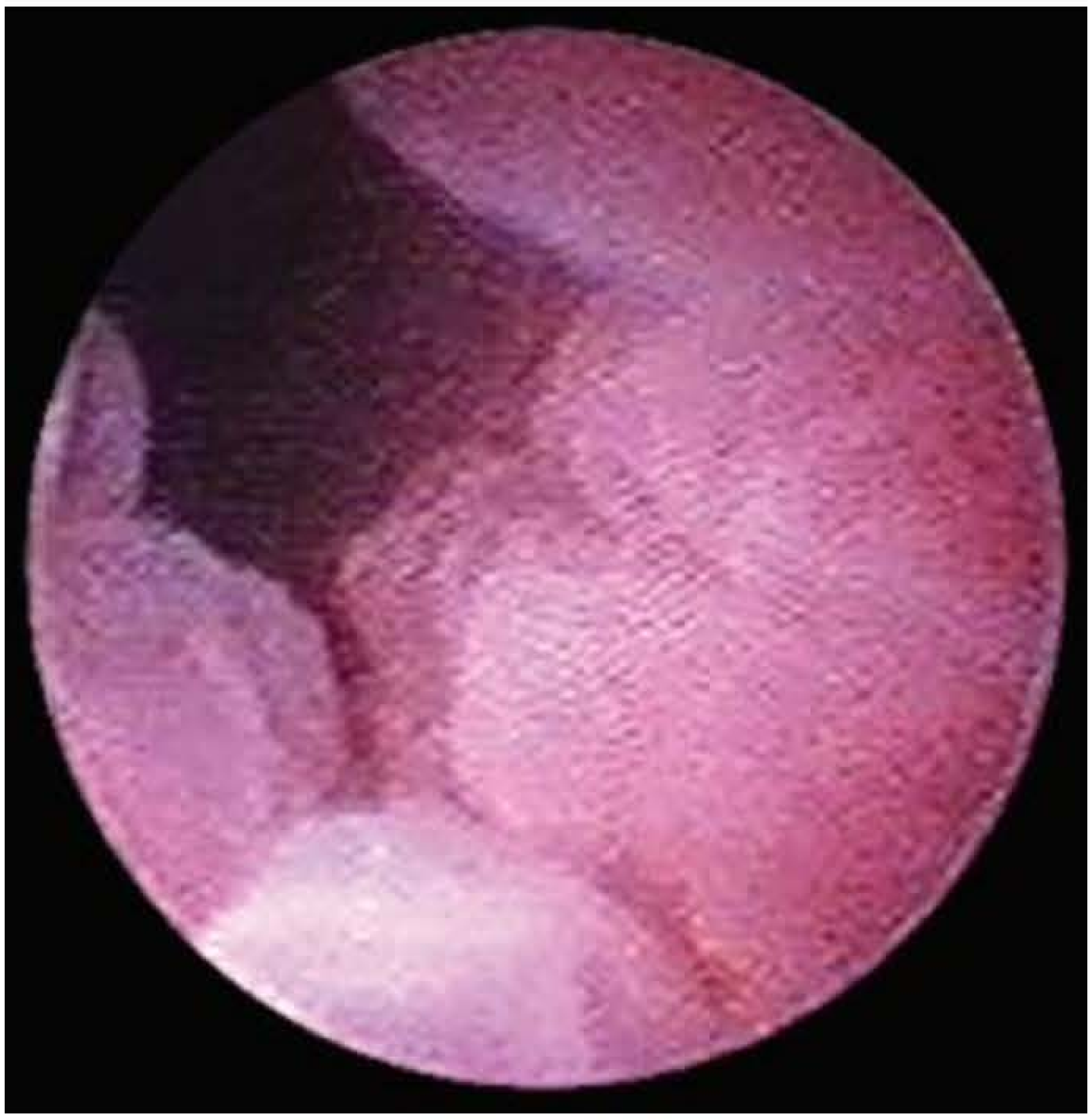


Figure 6.45 Important edema of the ureter.

6.4. Flexible retrograde ureteroscopy technique

Theoretically, flexible ureterorenoscopy allows for the endoscopic approach of the entire upper urinary tract. Despite the technological advances, this method's efficiency is limited by the impossibility of using certain rigid accessory instruments, by the small-caliber working channel, and by the lower reliability of rigid ureteroscopes.

6.4.1. Preliminary Measures

The preoperative preparation measures are similar to those preceding rigid and semirigid retrograde approach, with several specific particularities.

6.4.1.1. Patient Position

In most cases, retrograde flexible ureteroscopy is performed in the standard lithotomy position. It has been recommended to position the patient in Trendelenburg and with the part ipsilateral of the approached kidney slightly ascended. Thus, during lithotripsy, any migration of the lithiasic fragments will occur toward the renal pelvis and the middle or upper calyces, therefore in a position easier to approach. In particular situations, the intervention can also be performed in special positions.

When retrograde flexible ureteroscopy is performed simultaneously with the percutaneous approach of the kidney, it is recommended that the patient be placed in the procubitus position, with the lower limbs apart, so that the operator can have access to the penis and the urethra (Marguet et al., 2005) (Fig. 6.46). Another special position is in lateral decubitus, with the part that is to be approached oriented superiorly (Fig. 6.47).

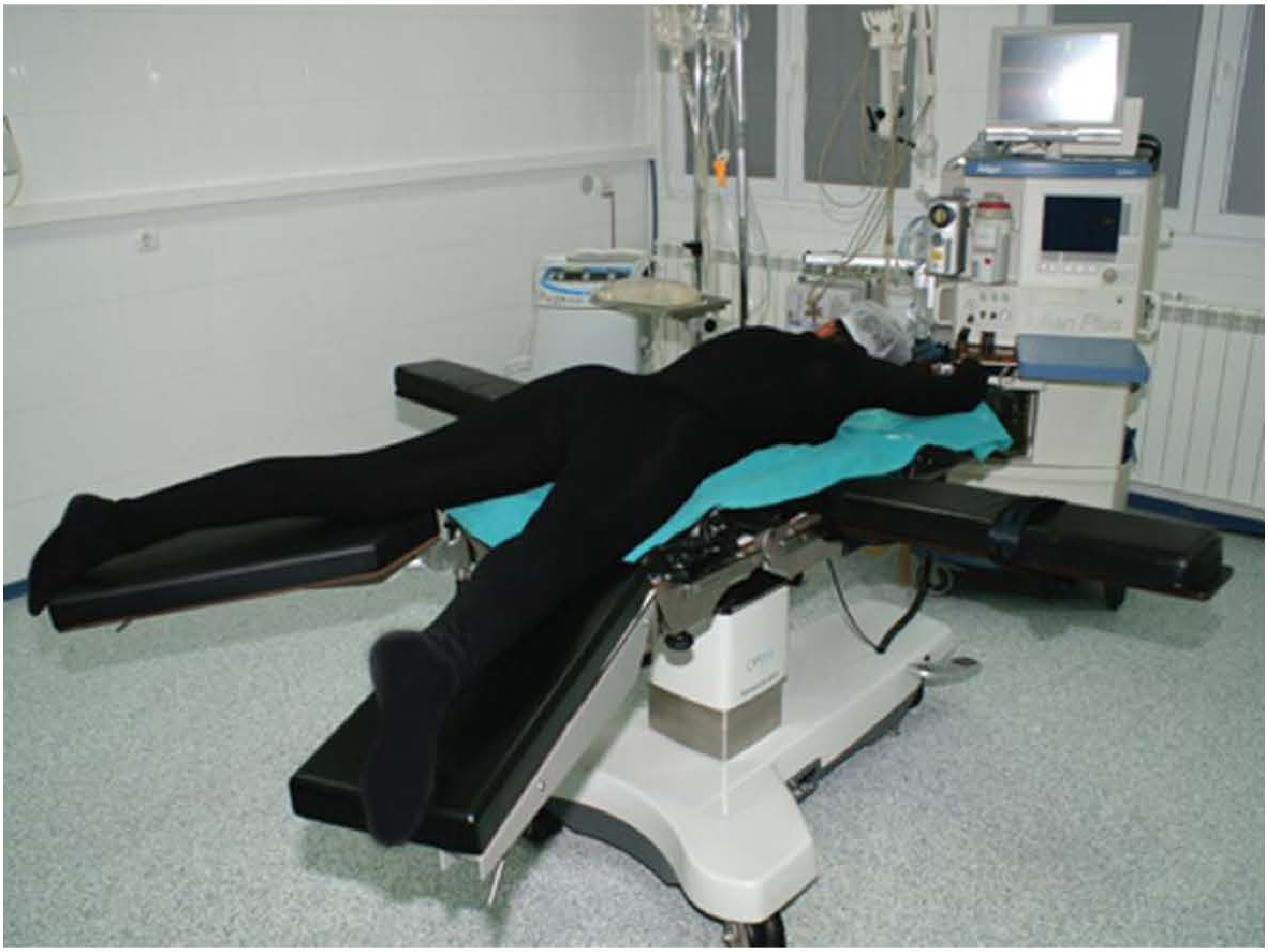


Figure 6.46 **Dorsal position for retrograde ureteroscopic approach.**

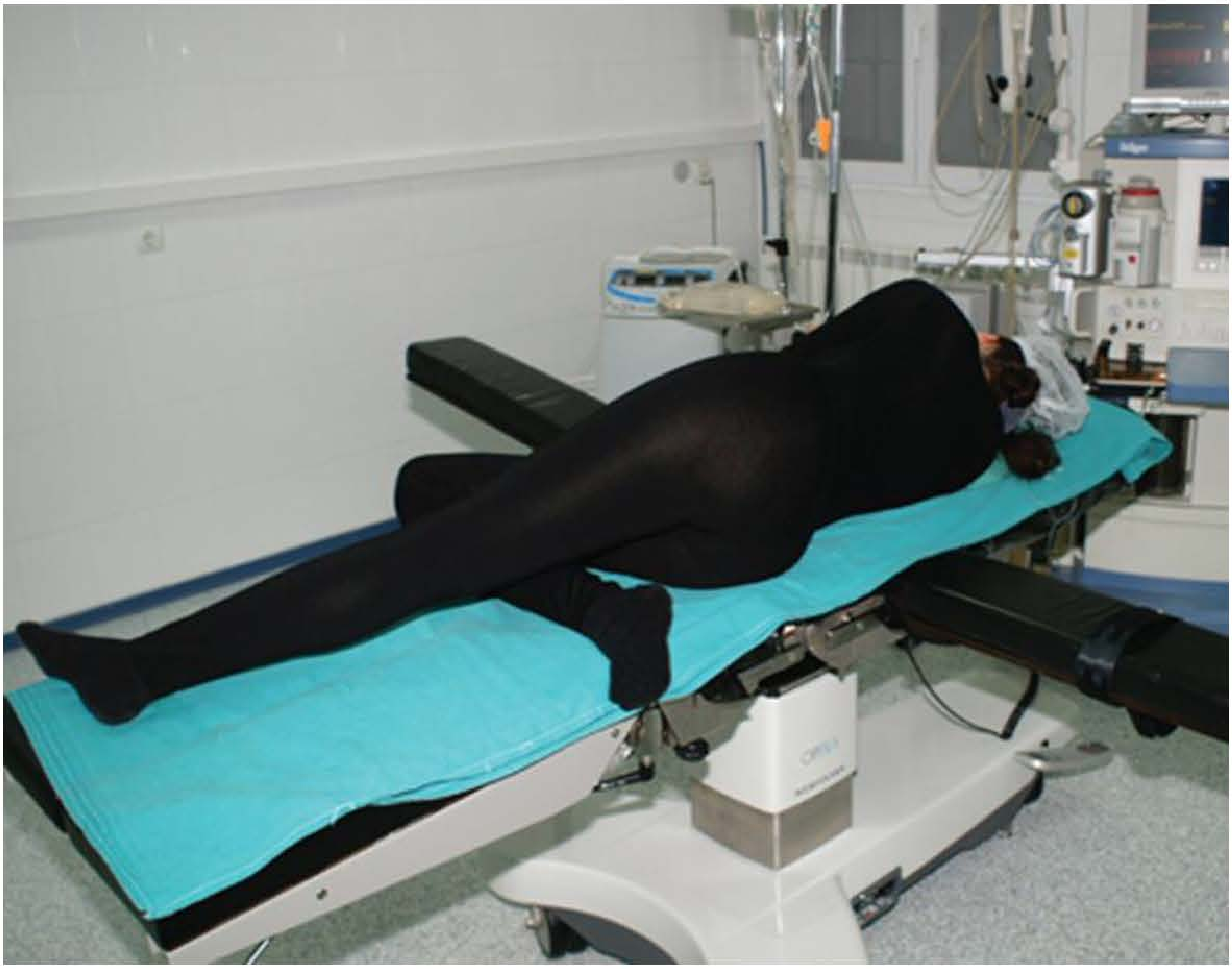


Figure 6.47 **Lateral position for retrograde ureteroscopic approach.**

This position may be useful during retrograde flexible interventions in patients with complex lithiasis (large lithiasic mass, coraliform stones, etc.). Due to the fact that the renal pelvis becomes the lowest part of the pyelocaliceal system, the stones will migrate to this level during lithotripsy, thus becoming easier to fragment and to extract (Herrell and Buchanan, 2002). This position can also be used when retrograde flexible ureteroscopic approach and percutaneous approach are performed simultaneously (Undre et al., 2004).

6.4.1.2. Anesthesia

Similar to rigid and semirigid ureteroscopy, the flexible ureteroscopic procedures can be performed under general, spinal, peridural, or local anesthesia. Due to the reduced aggression on the upper urinary tract and to the lower flow of the irrigation fluid, a high percentage of flexible ureteroscopic interventions can be performed under local anesthesia, with or without sedoanalgesia (Cybulski et al., 2004).

6.4.2. Cystoscopy and Placing the Guidewires

This step is performed in a manner similar to the maneuvers described during rigid or semirigid ureteroscopy.

The guidewire must surpass any lesion of the upper urinary tract and will be ascended until its soft end encoils at the pyelocaliceal level. This is the safety guidewire and plays an essential role in maintaining access to the upper urinary tract, allowing for repeated passages of the ureteroscope. As a general rule, guidewires with a hydrophilic coating will not be used as safety guidewires, due to the risk of descendent migration from the upper urinary tract.

A second guidewire is placed afterward, over which the flexible ureteroscope is introduced, sliding it up to the ureteral level. Placing the two guidewires up to the renal pelvis can be achieved with the help of a 10 F two-lumen catheter (Kumar et al., 2001).

6.4.3. Dilation of the Uretero-Vesical Junction

Dilation of the ureteral orifice can also be necessary in case of flexible ureteroscopy and is performed by one of the previously described methods. Nevertheless, routine dilation of the intramural ureter is no longer required in case of using flexible ureteroscopes smaller than 9 F.

Most models have a diameter of the distal end smaller than that of the sheath, allowing for an easy insertion into the ureteral orifice. The instrument's caliber increases progressively, achieving a sufficient dilation simply by ascending it into the ureter.

6.4.4. Ascending the Flexible Ureteroscope

Insertion of the flexible ureteroscope into the upper urinary tract can be achieved by different methods.

One of these procedures is represented by sliding the ureteroscope over the guidewire (after retrogradely passing its rigid end through the working channel), and advancing it, relatively easily, along the urethra, through the urinary bladder, up to the ureteral orifice.

In many flexible ureteroscopes, the working channel is located eccentrically. Due to this design, it is necessary to orient the distal end so that the channel is oriented vertically and the superior margin of the ureteral orifice is not hooked during the insertion attempt. This maneuver is no longer necessary with new models, which have a small caliber and a centrally located working channel. Some flexible ureteroscopes have an oblique distal end. This particular shape allows for "loading" the free margin of the ureteral orifice and facilitates the endoscope's insertion into the upper urinary tract.

Another insertion variant is represented by passing the flexible ureteroscope through the sheath of a cystoscope with the optics removed, positioned with the distal end at the level of the ureteral orifice. Thus, the risk of coiling the flexible endoscope in the urinary bladder is prevented.

The flexible ureteroscope can also be ascended through the sheath of a 14 F rigid ureteroscope, placed anteriorly in the ureter and with the optics removed. Sealing is achieved by passing the flexible endoscope through a latex diaphragm placed on the rigid sheath (Bagley, 1988a, b).

As an alternative, the flexible ureteroscope can be inserted on a ureteral access sheath (Fig. 6.48). A Teflon dilator equipped with a coaxial sheath is advanced on the guidewire placed under cystoscopic control. The distal end will be ascended until it is below the stone in case of ureteral lithiasis, or up to the ureteropelvic junction in case of pyelocaliceal lithiasis. The correct positioning can be checked by injecting contrast media through the dilator's lumen. The latter will be removed, only the sheath remaining in the ureter, thus ensuring safe and easy access to the upper urinary tract. The metallic guidewire can be kept on the sheath or can be extracted, according to the operator's preference. The flexible ureteroscope easily reaches the lesion, and other auxiliary instruments can be introduced alongside it.

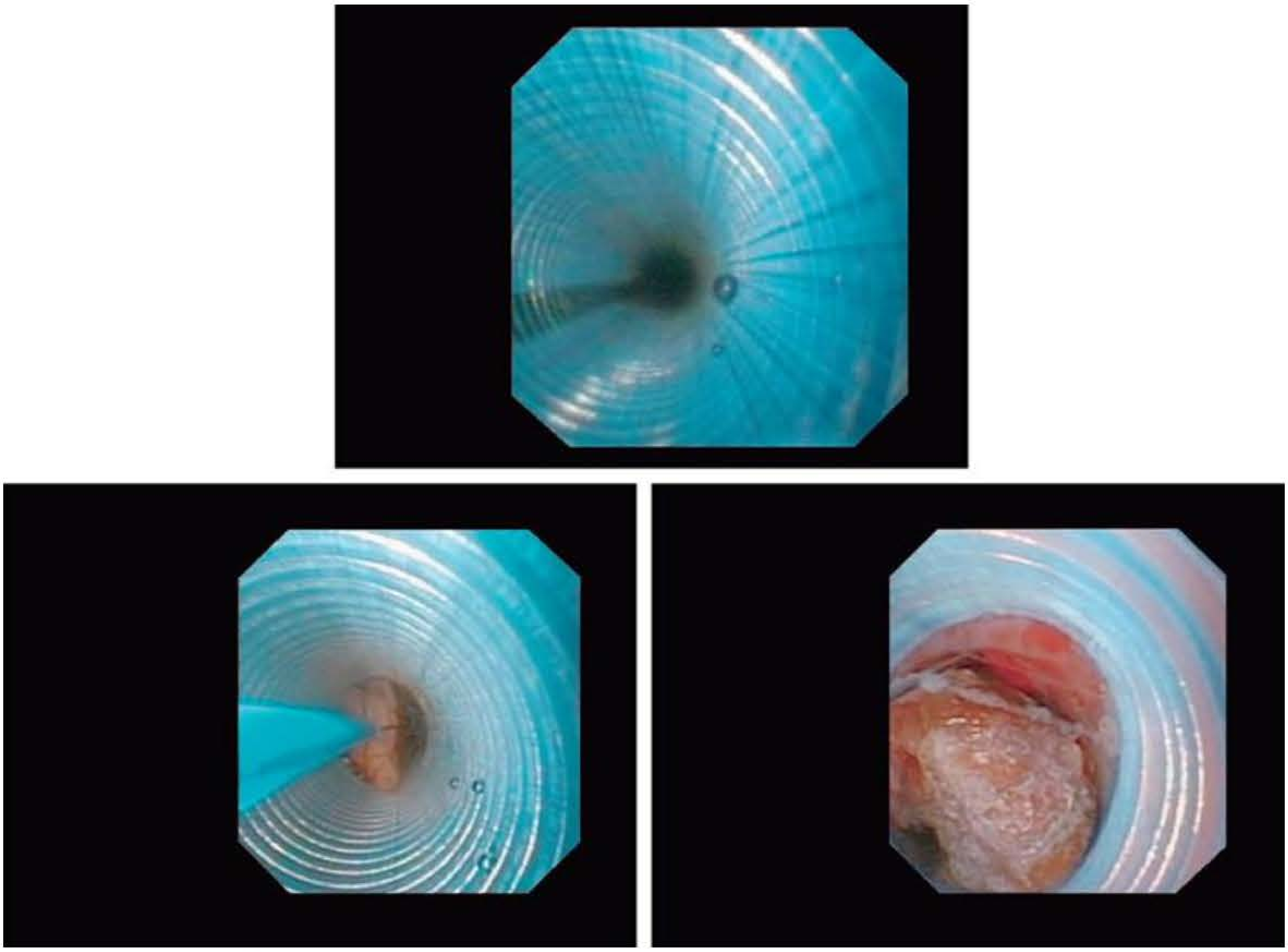


Figure 6.48 **Flexible ureteroscope inserted on the ureteral access sheath.**

The flexible ureteroscope can also be inserted directly, under visual control, in patients with percutaneous ureterostomy, if the ureteral orifice and lumen have adequate dimensions. The instrument can be advanced merely by pushing it, the risk of coiling being practically zero.

At the ureteral level, the flexible ureteroscope will be advanced by sliding over the guidewire (Fig. 6.49). Maintaining its distal end at the pyelic level and the absence of the ureteroscope's coiling in the urinary bladder must be checked by fluoroscopy. Once it has reached the ureter, the endoscope will be gradually advanced up to the renal pelvis, under fluoroscopic guidance or by direct visualization.

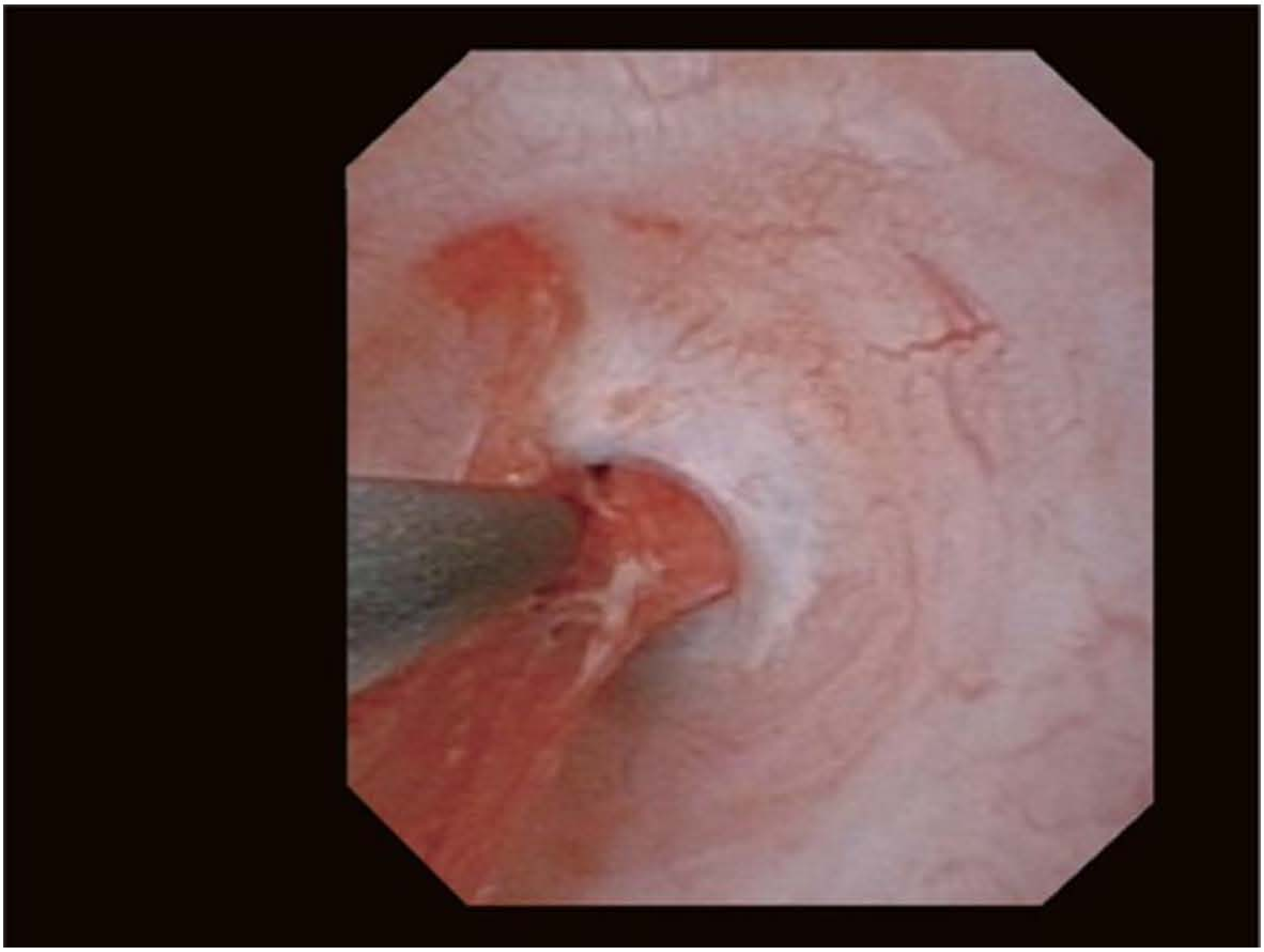


Figure 6.49 **Ascending the digital flexible ureteroscope into the ureter by sliding over the guidewire.**

In case of this last variant, the aim is to permanently maintain the ureteral lumen in the center of the endoscopic field, hydrodilation frequently being necessary. By adding contrast media in the irrigation fluid, the ureteral sinuosities can be fluoroscopically observed and surpassed one by one, using the ureteroscope's deflection.

After the distal end of the flexible ureteroscope reaches the pyelic level, the working guidewire will be extracted, only the safety guidewire remaining in position.

When the ureteropelvic junction has a small caliber preventing the passage of the endoscope, its dilation with a balloon catheter may be necessary.

6.4.5. Orienting the Ureteroscope at the Pyelocaliceal Level

At the level of the pyelocaliceal system, the flexible ureteroscope is maneuvered under fluoroscopic control, by injecting 30–50% contrast media through the working channel (Fig. 6.50). In general, the radiological localization and guidance of the endoscope's distal end is easier than the direct endoscopic visual one.

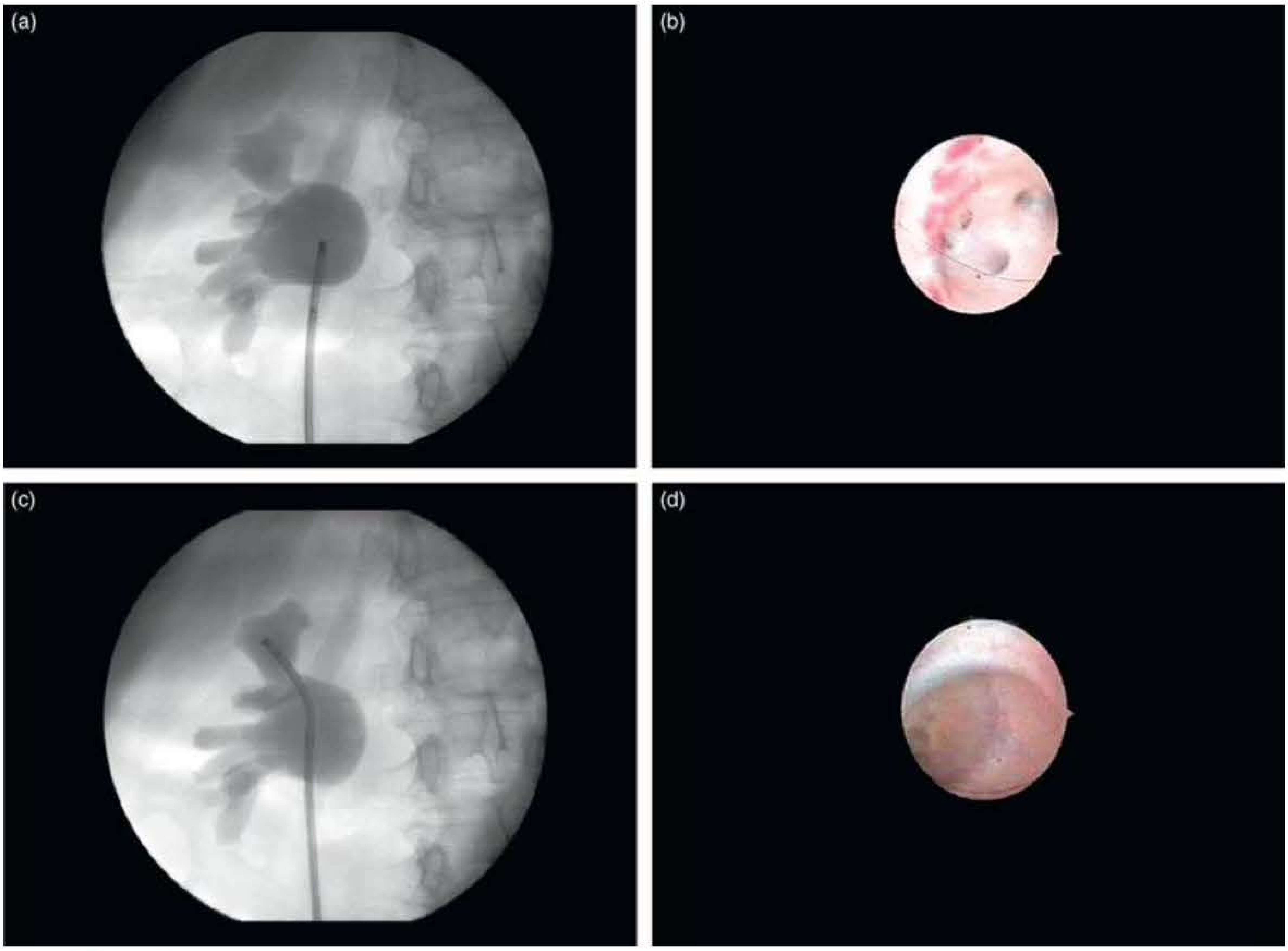


Figure 6.50 **Checking the position of the ureteroscope by correlating the radiological images with the endoscopic ones.**

Inspection of the renal pelvis (a, b), inspection of the upper calyces (c, d).

The ideal flexible ureteroscope should present a balance between maneuverability and ease of insertion. This should have a rigidity of the sheath sufficient enough to provide stability, but also adequate possibilites for active and passive deflection in order to be maneuverable in the renal collecting system (Parkin et al., 2002).

6.4.6. Fragmenting and/or Extracting the Calculi

For ureteral lithiasis, small calculi can be extracted en bloc, with flexible tripod and grasper clamps or with basket catheters (Fig. 6.51), the latter presenting a higher risk of ureteral avulsion. For this reason, the extraction maneuvers should be performed gently, avoiding excessive traction, regardless of the situation. Lithotripsy can be electrohydraulic or laser, and will be performed until fragments smaller than 4 mm are obtained, which can be extracted safely. In order to avoid intraoperative complications, the electrohydraulic lithotripsy probes or the laser fibers must be oriented toward the stone, along a direction as parallel as possible to the ureteral wall.

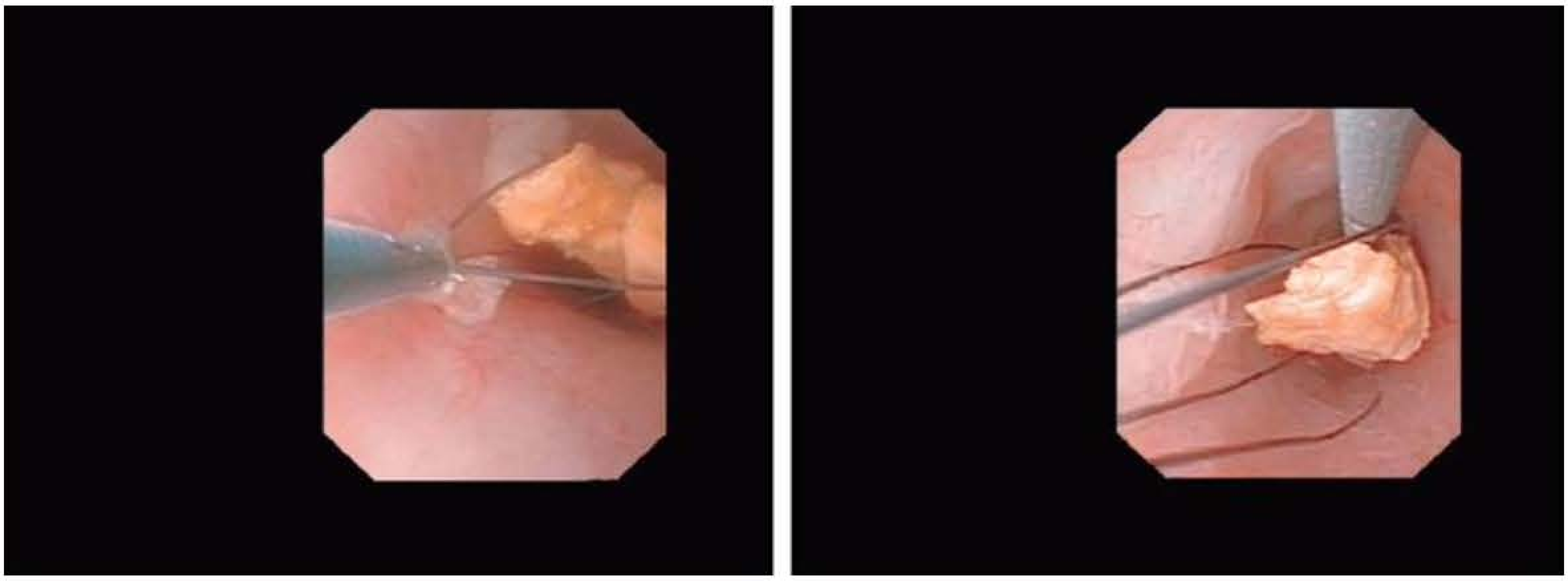


Figure 6.51 Extraction of ureteral lithiasic fragments with basket catheters.

For pyelocaliceal lithiasis, single or multiple small calculi (Figs 6.52–6.54) can be extracted using flexible clamps (Figs 6.55 and 6.56) or basket catheters (Fig. 6.57).

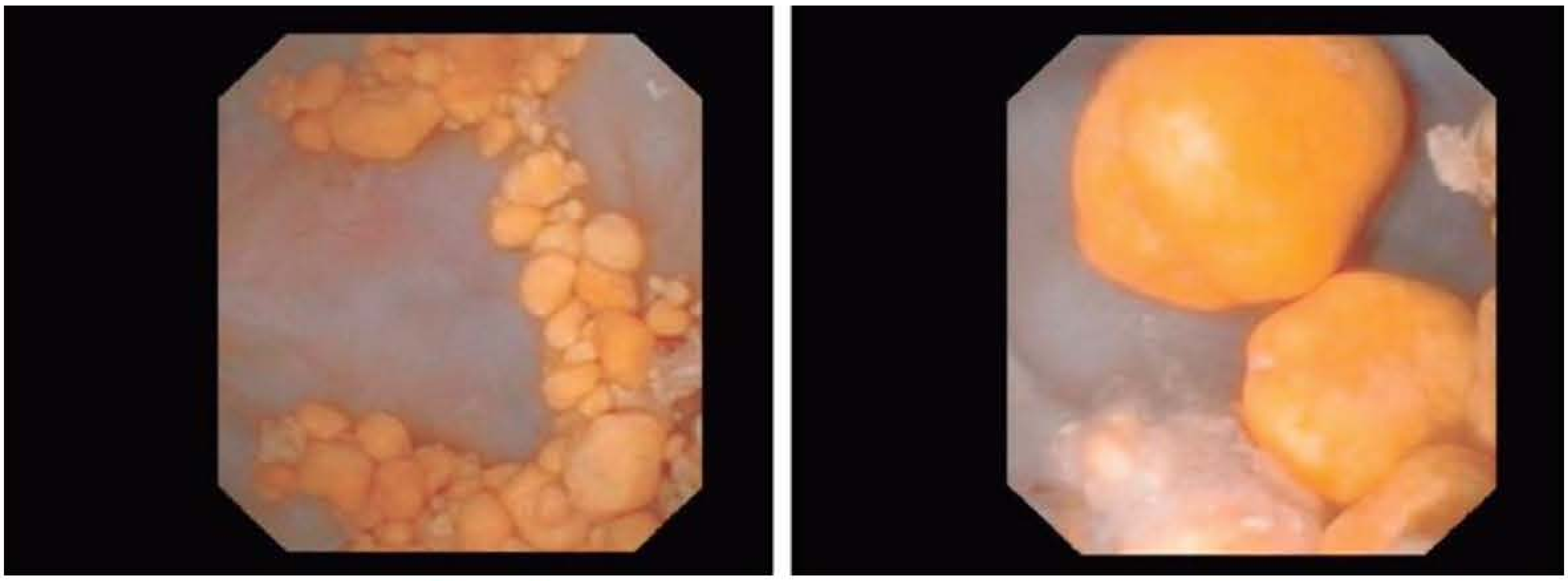


Figure 6.52 Small, multiple pyelocaliceal lithiasis.

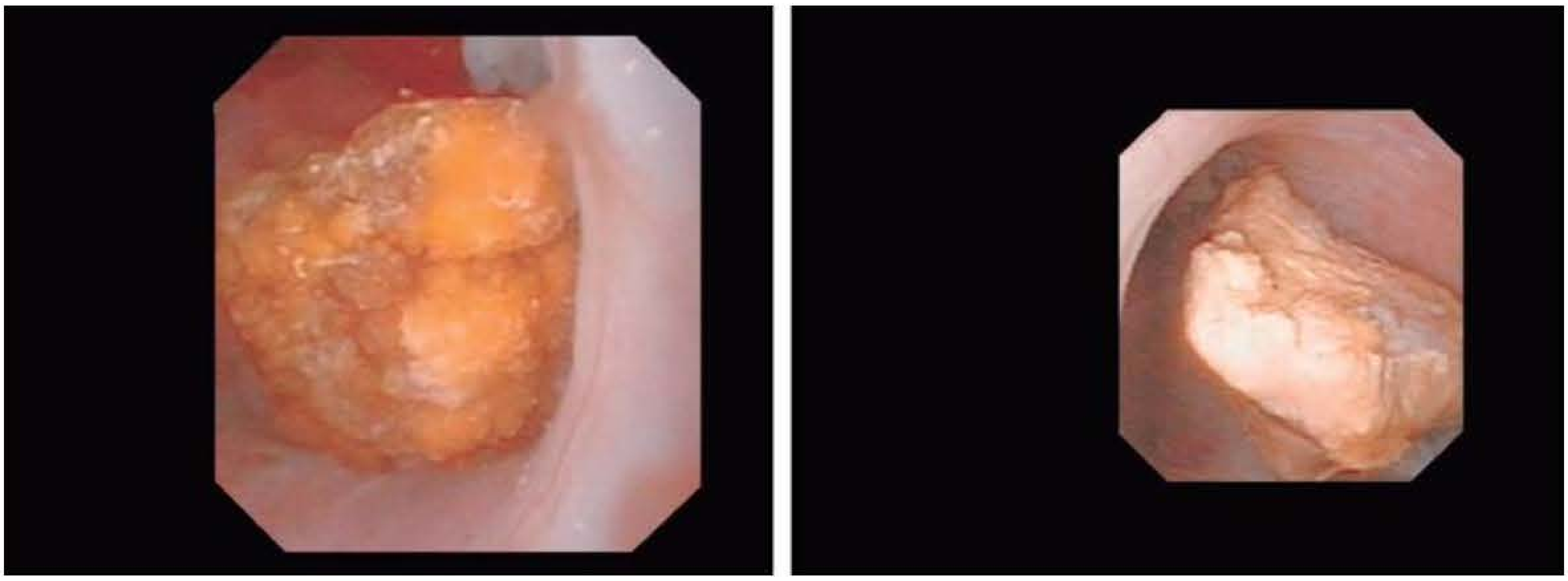


Figure 6.53 Solitary caliceal calculi.

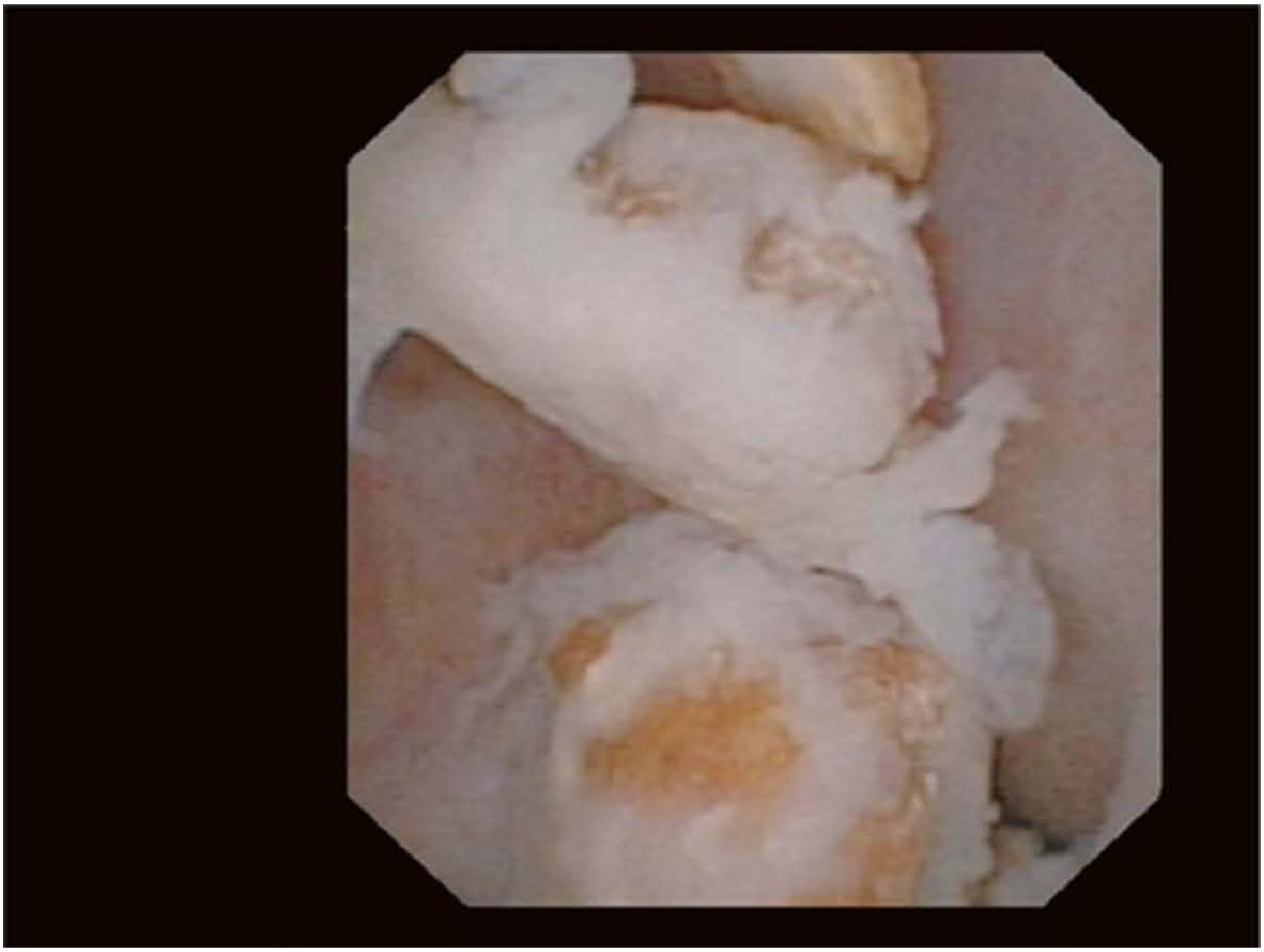


Figure 6.54 Multiple caliceal calculi associated with soft lithiasis.

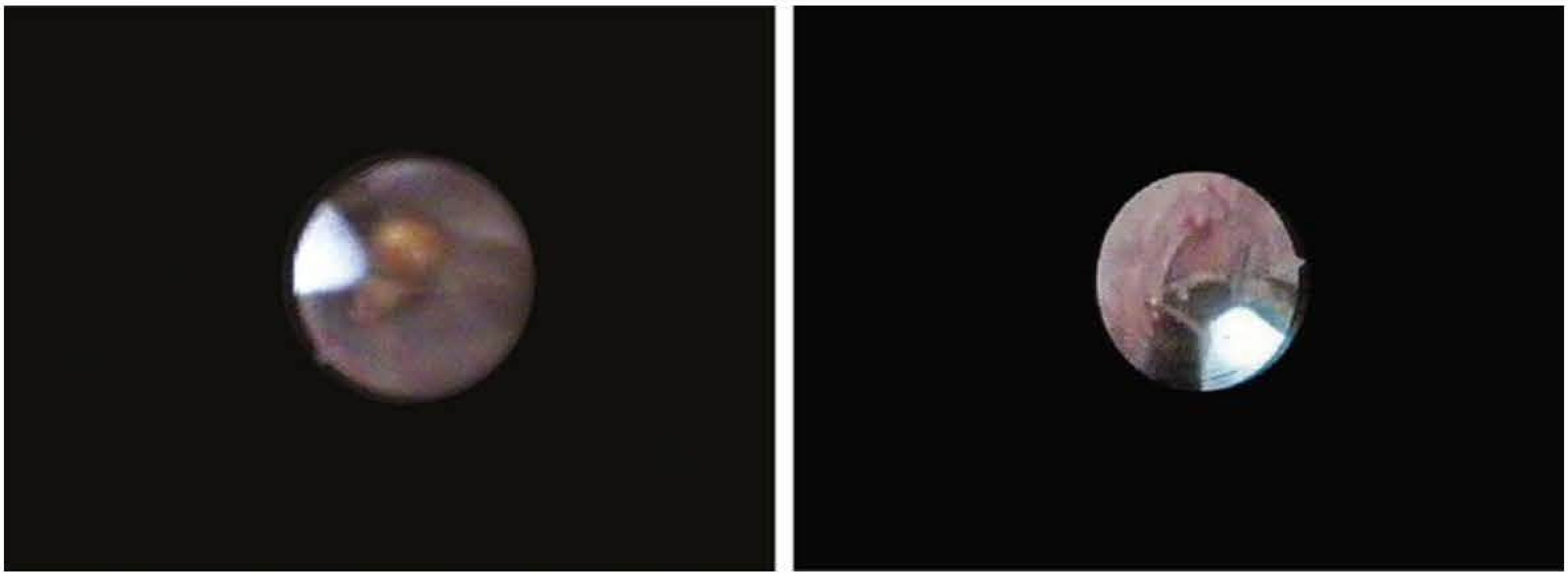


Figure 6.55 Extraction of caliceal calculi with the flexible ureteroscope, using the tripod grasper clamp.

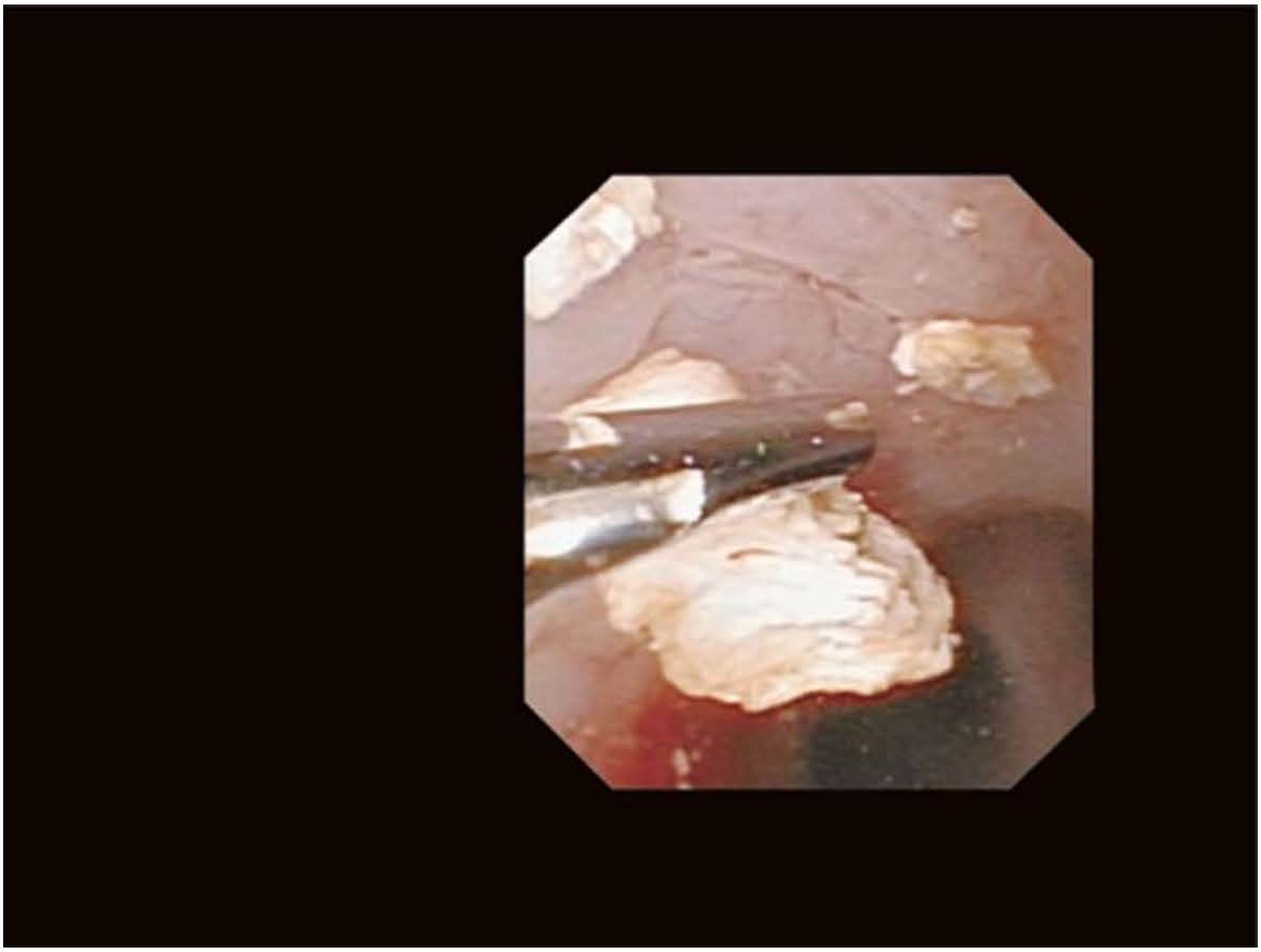


Figure 6.56 Extraction of a caliceal lithiasic fragment with a flexible clamp.

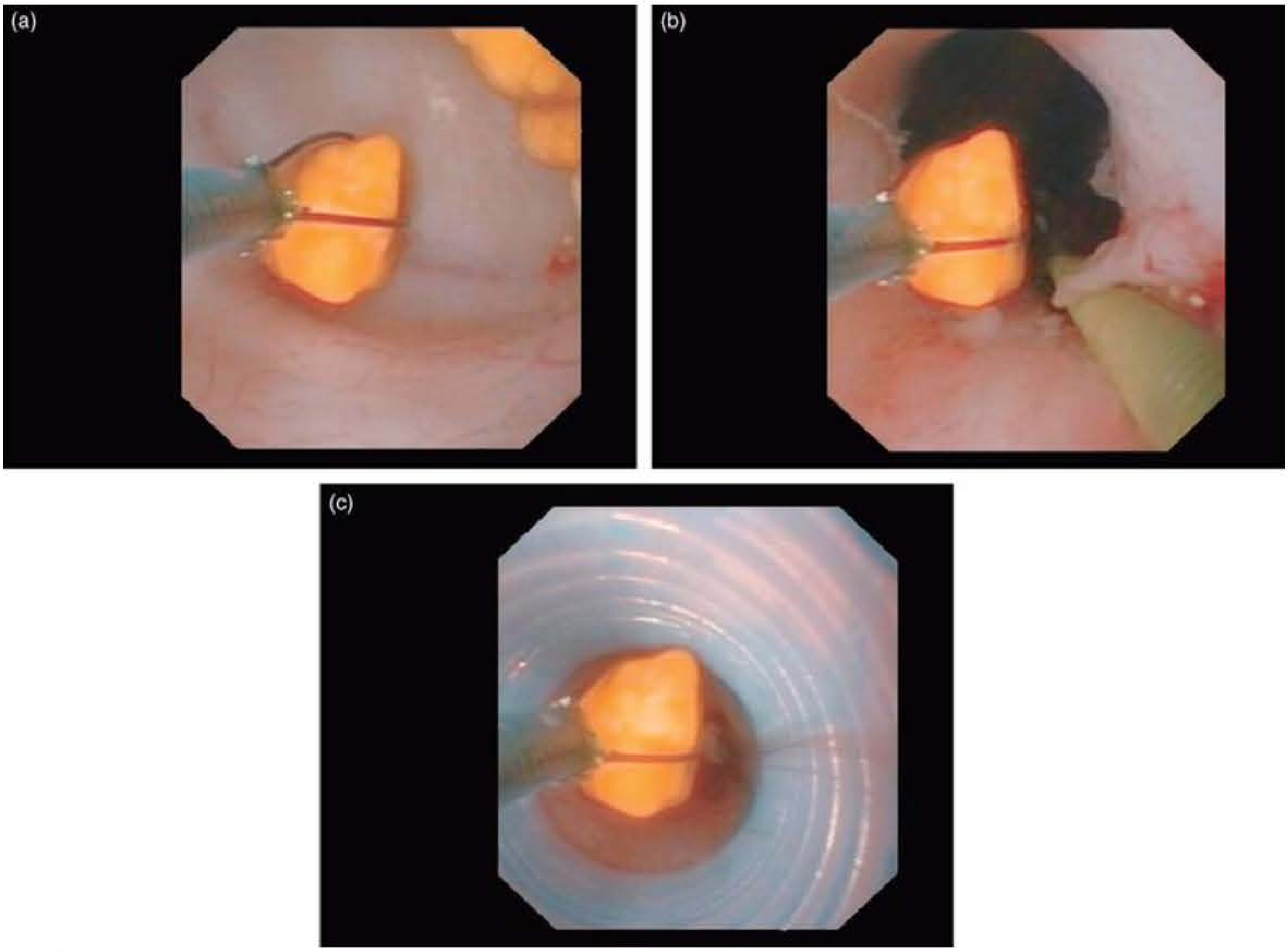
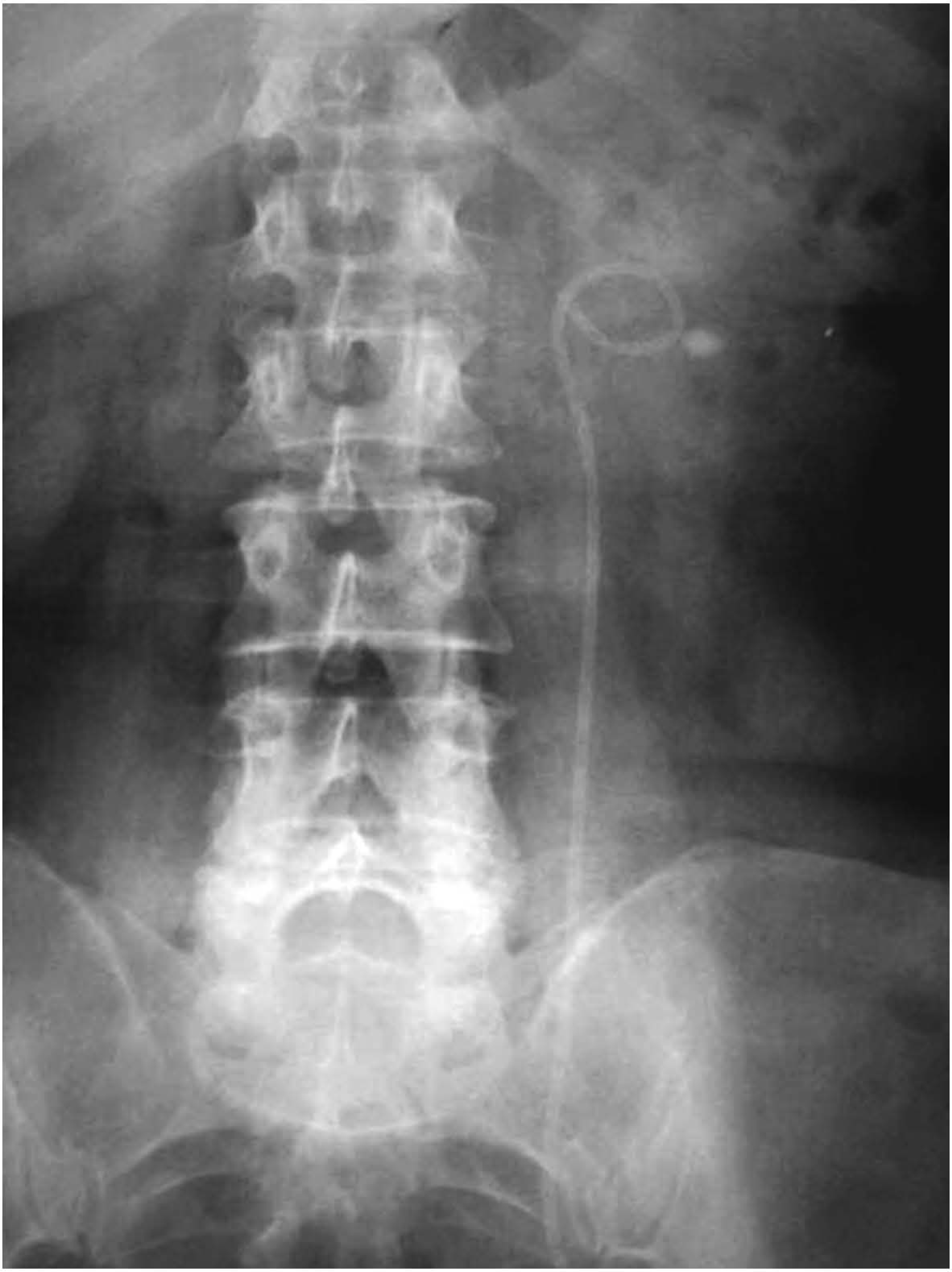


Figure 6.57 **Extraction of a caliceal stone with a basket catheter (a), through the renal pelvis (b), and through the ureteral access sheath (c).**

Intracorporeal lihotripsy of the calculi is necessary in the vast majority of cases. This can be performed "*in situ*" or after moving them into another region of the pyelocaliceal system.

"*In situ*" lithotripsy is performed when the lithiasic fragments are easy to approach, even if the flexible ureteroscope has a reduced deflection due to the accessory instruments inserted through the working channel (usually pyelic, middle, or upper caliceal calculi) (Figs 6.58 and 6.59).



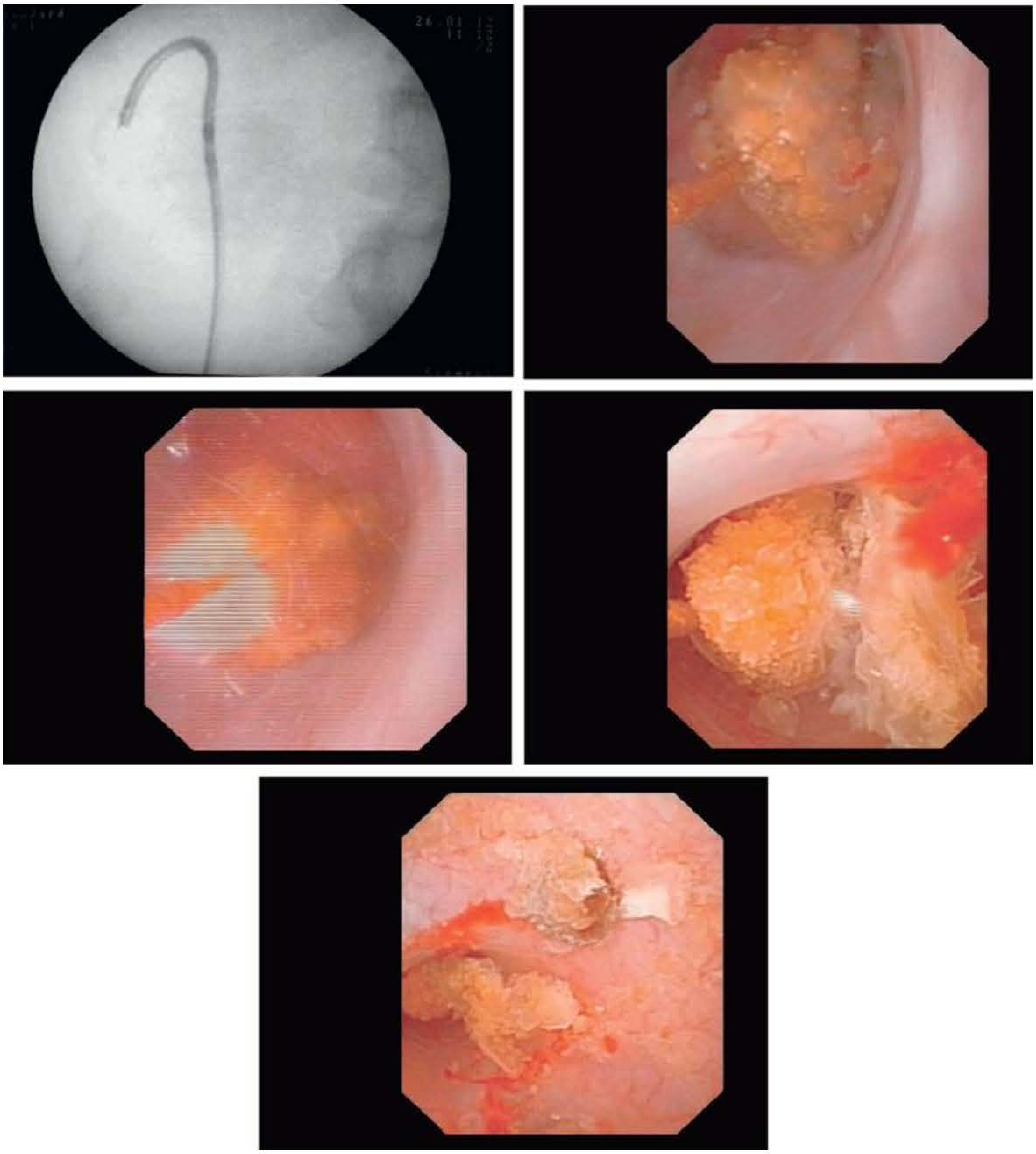
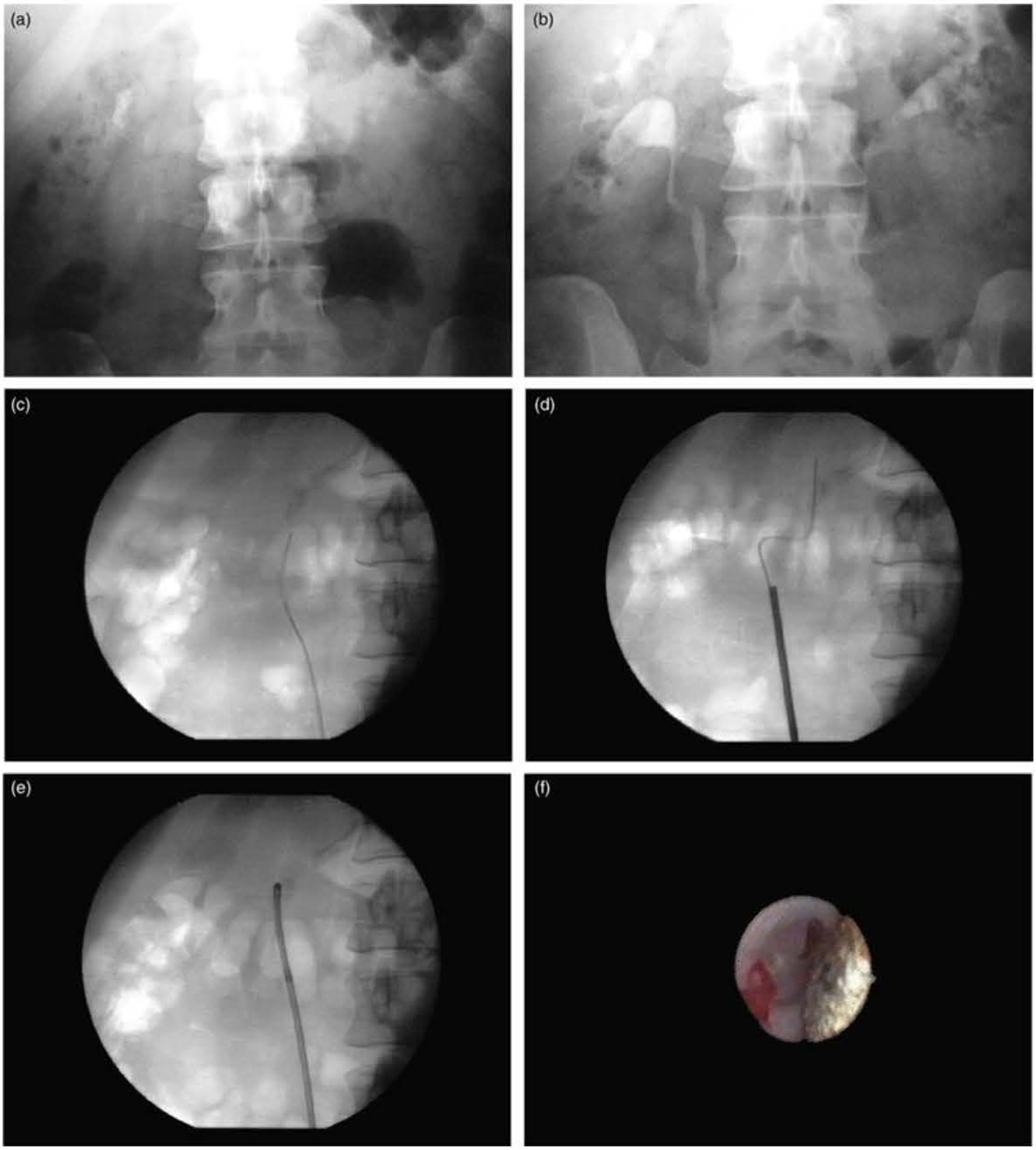


Figure 6.58 ***In situ* electrohydraulic lithotripsy of a caliceal stone into 2 mm fragments.**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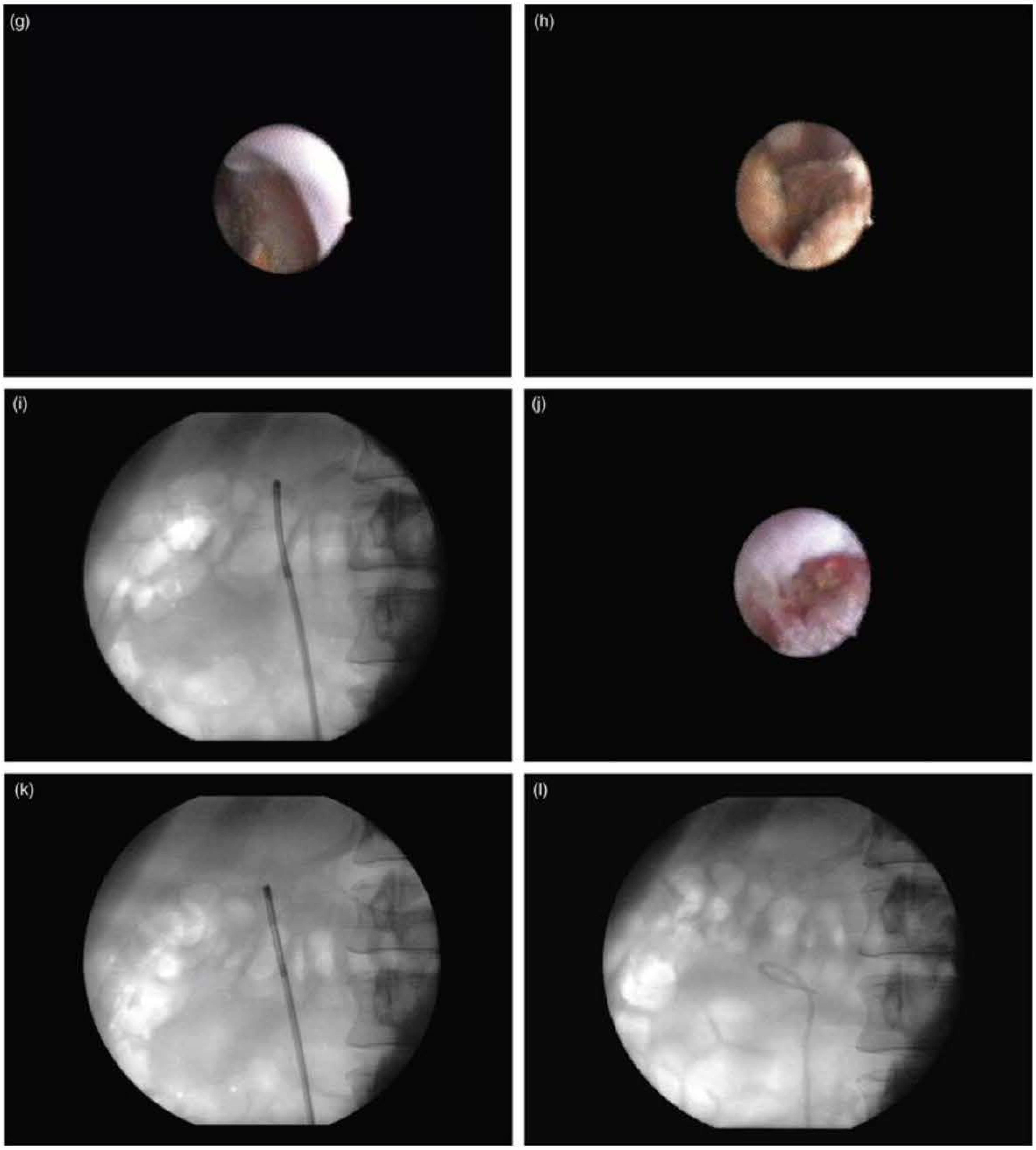


Figure 6.59 Flexible ureteroscopic treatment of an upper caliceal stone (a, b), inaccessible with semirigid instruments (c, d): flexible ureteroscopic approach of the upper calyx (e, f), electrohydraulic lithotripsy of the stone (g–i), stone-free aspect of the upper calyx (j), small (<2 mm) pyelocaliceal lithiasic fragments (k), JJ stent placed at the end of the intervention (l).

The approach of lower caliceal calculi (Fig. 6.60) may raise a series of problems, especially when flexible ureteroscopes with a single active deflection are used.

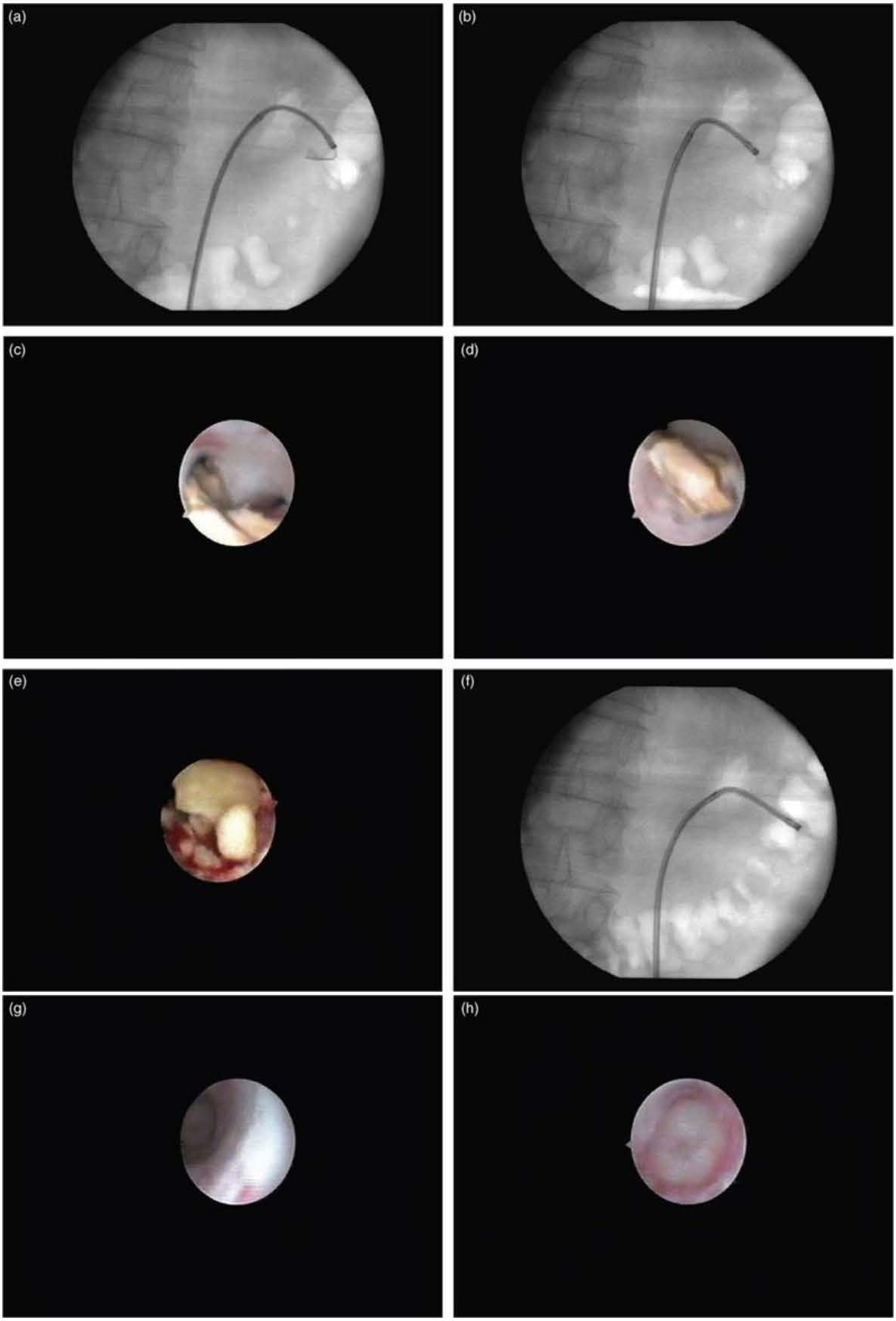


Figure 6.60 Flexible ureteroscopic treatment of a lower caliceal stone. Flexible ureteroscopic approach of the lower calyx (a–d), electrohydraulic lithotripsy of the stone (e), stone-free aspect at the end of the intervention (f–h).

In order to achieve the passive deflection, the distal area of the flexible ureteroscope must lean on the superior wall of the renal pelvis or in the area of implantation of the middle or upper caliceal infundibula (Fig. 6.61).

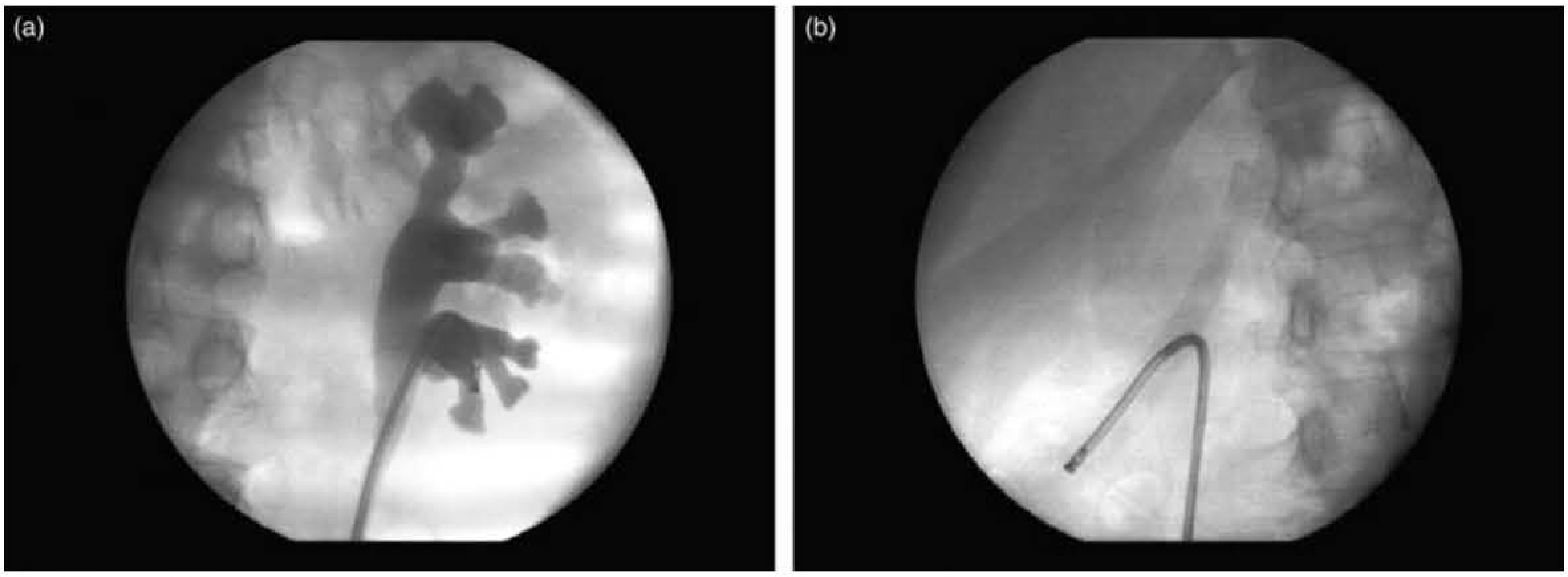


Figure 6.61 **Flexible ureteroscopic approach of the lower calyx using active (a) and passive (b) deflection, respectively.**

Certain anatomical particularities (small infundibulopelvic angle, increased length, or reduced caliber of the lower caliceal infundibulum) or pathological modifications (hydronephrosis) may limit the access of these flexible ureteroscopes to the lower renal pole (Geavlete et al., 2007c).

Sometimes, stones located at this level can only be visualized by flexible ureteroscopy, but due to the reduced amplitude of the deflection as a result of the insertion of different accessories through the working channel, they can no longer be approached for lithotripsy. In these situations, it is preferred to first mobilize the stone. This will be caught in a basket catheter and moved into the renal pelvis or upper calyx, where lithotripsy will be performed (Fig. 6.62). If the insertion of the basket catheter into the working channel reduces the amplitude of the deflection too much, the extracting instrument can be disassembled and inserted without its external cover.

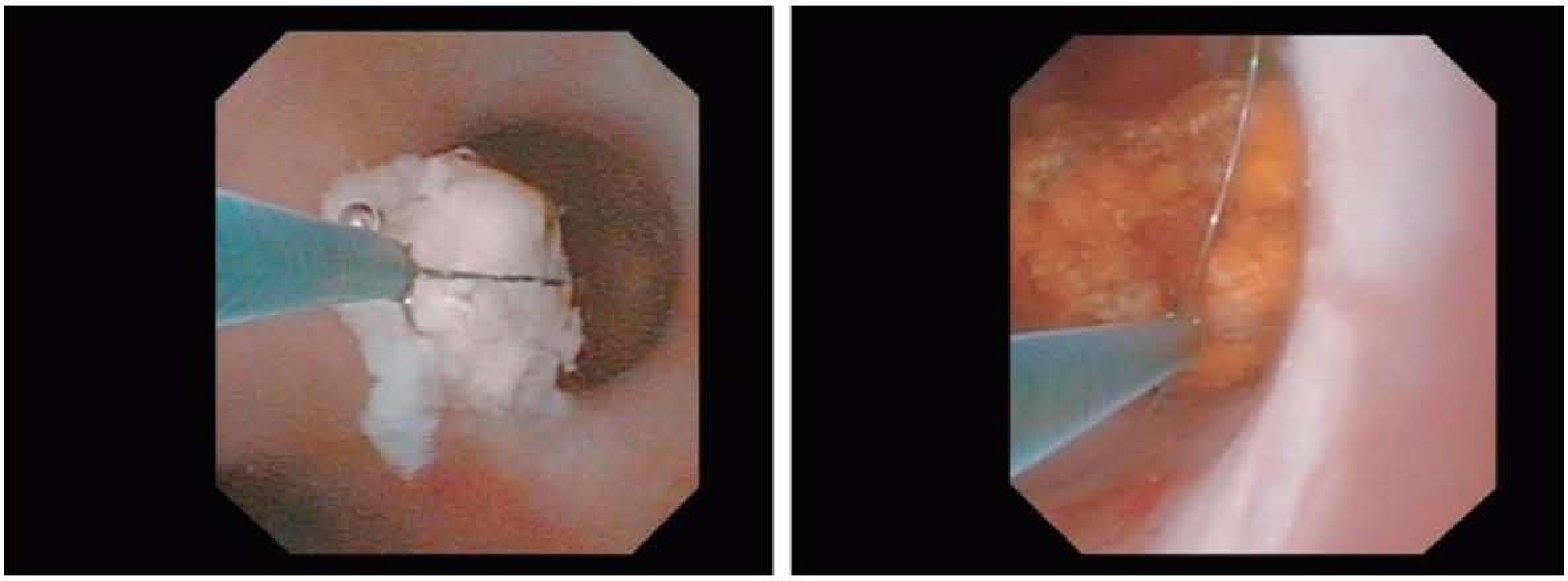


Figure 6.62 **Repositioning lower caliceal calculi in the renal pelvis.**

For manipulating and extracting caliceal lithiasic fragments, it is recommended to use basket catheters without a tip, which have a design that reduces the risk of injuring the adjacent tissues (Figs 6.63 and 6.64).

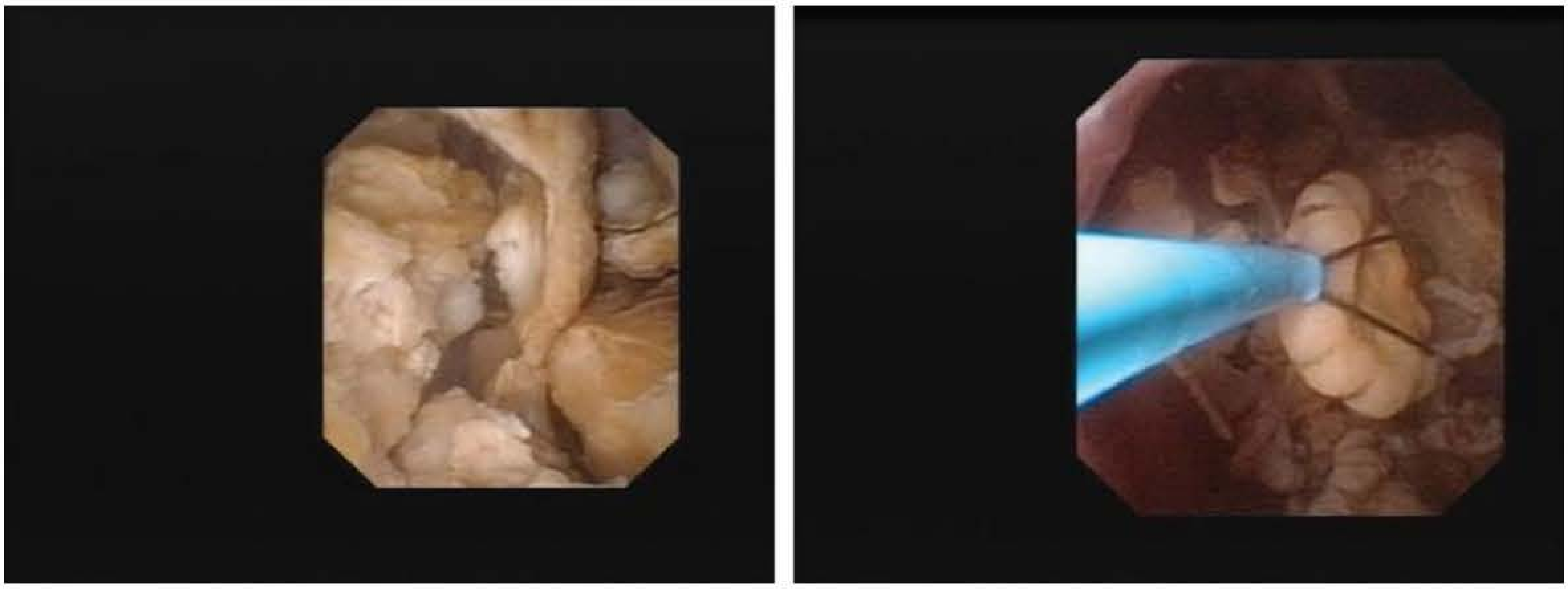


Figure 6.63 Extracting the probe basket lithiasic clipped fragments obtained by laser lithotripsy.

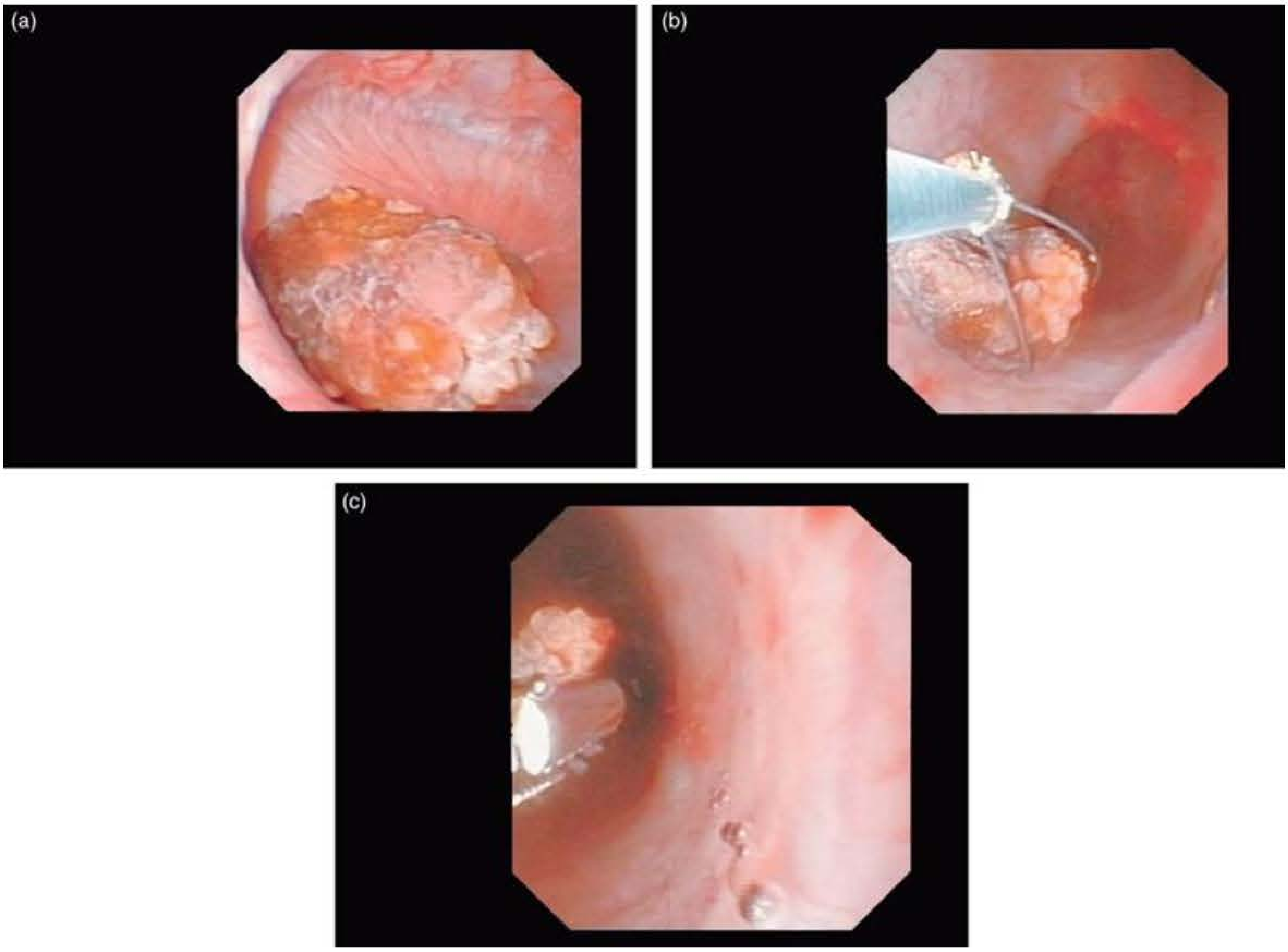


Figure 6.64 Extraction with a basket catheter of a caliceal stone (a, b) and with a flexible clamp of a pelvic fragment (c).

In extreme situations, the approach of the lower calyx cannot be achieved even using a flexible ureteroscope with an empty working channel. Different techniques can also be used in this situation. The endoscope will be flexed in the renal pelvis so that the distal end of a guidewire inserted through the working channel is directed toward the lower renal pole. Subsequently, the flexible ureteroscope will slide over it up to the lower calyx. Other technical solutions can be represented by moving the stone from the lower calyx with the help of irrigation under pressure (Kumon et al., 2007) or injecting autologous blood through the working channel and extracting the lithiasic fragments in the blood clot thus formed.

The approach of the lower caliceal group is easier using new generation flexible ureteroscopes, which have two active deflections and one with a high amplitude (270°).

The fragmentation of the calculi is achieved using electrohydraulic or laser lithotripsy (Fig. 6.65). Positioning the patient in Trendelenburg and with the part ipsilateral with the lesion slightly ascendent aids migration of the lithiasic fragments toward the upper or middle calyx, where they are easier to approach. This has practical implications, especially since, during the intervention, due to the flow of the irrigation fluid (especially if this is done under pressure), it is to be expected that the pyelocaliceal system will dilate, which may make more difficult or even prevent passive secondary deflection and the approach of the lower calyx.

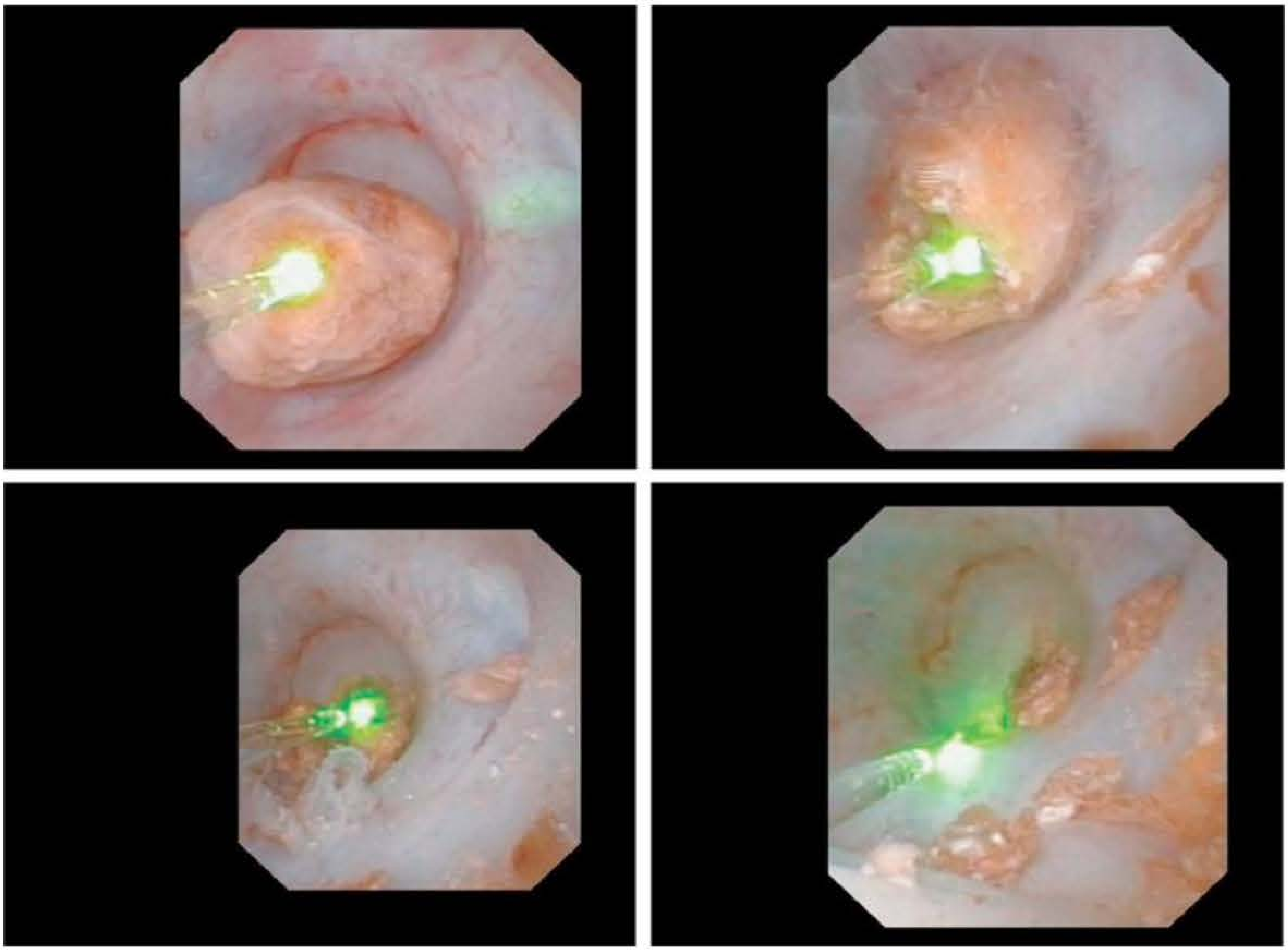
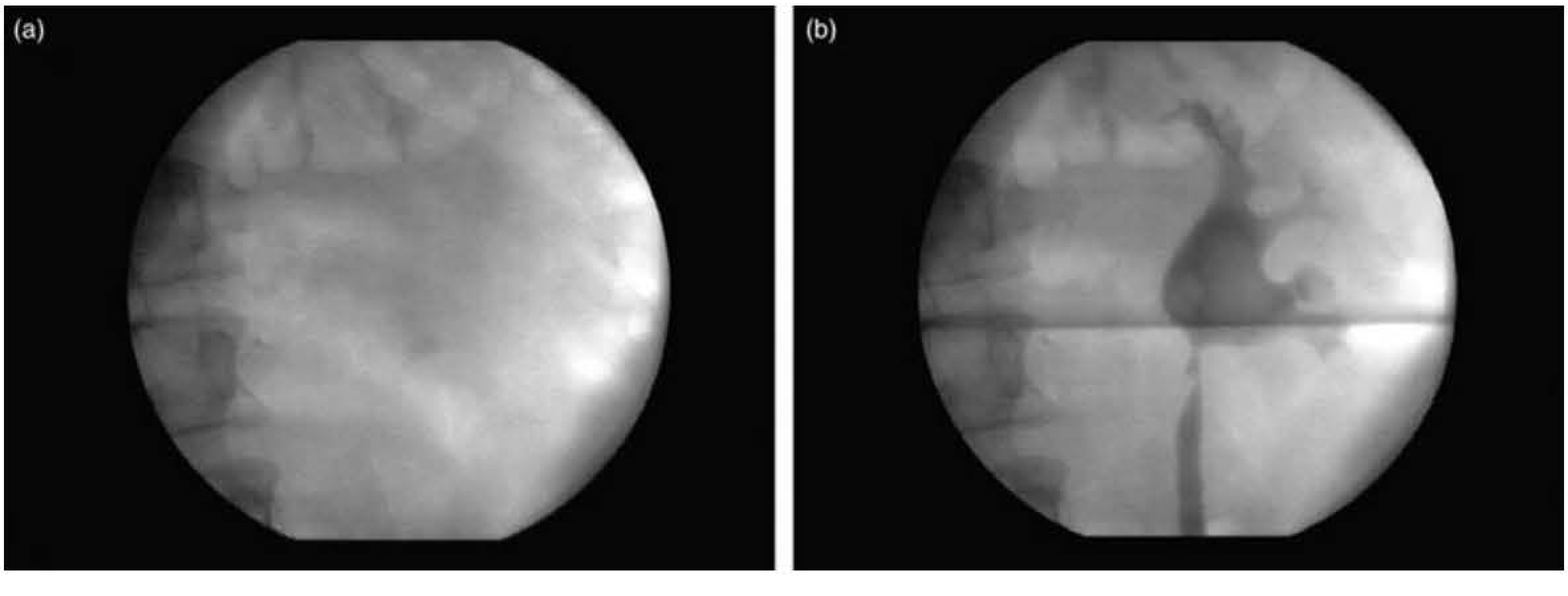
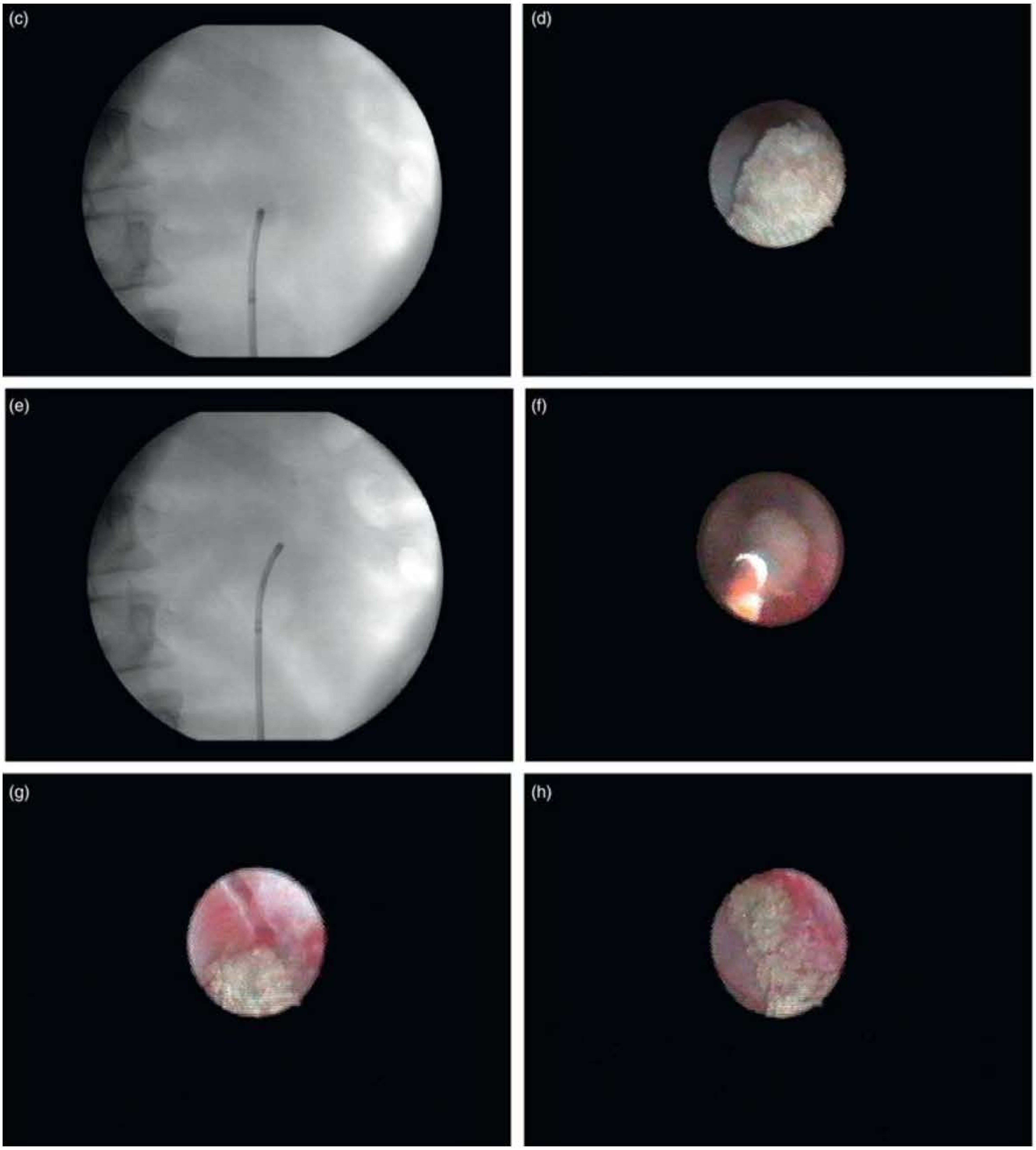


Figure 6.65 ***In situ* Ho:YAG laser lithotripsy of a lower caliceal stone.**

For electrohydraulic lithotripsy (Fig. 6.66), thin probes, of 1.6–1.9 F, will be used through the flexible ureteroscope. The risk of perforation is lower in case of using electrohydraulic lithotripsy for caliceal compared to ureteral lithiasis.

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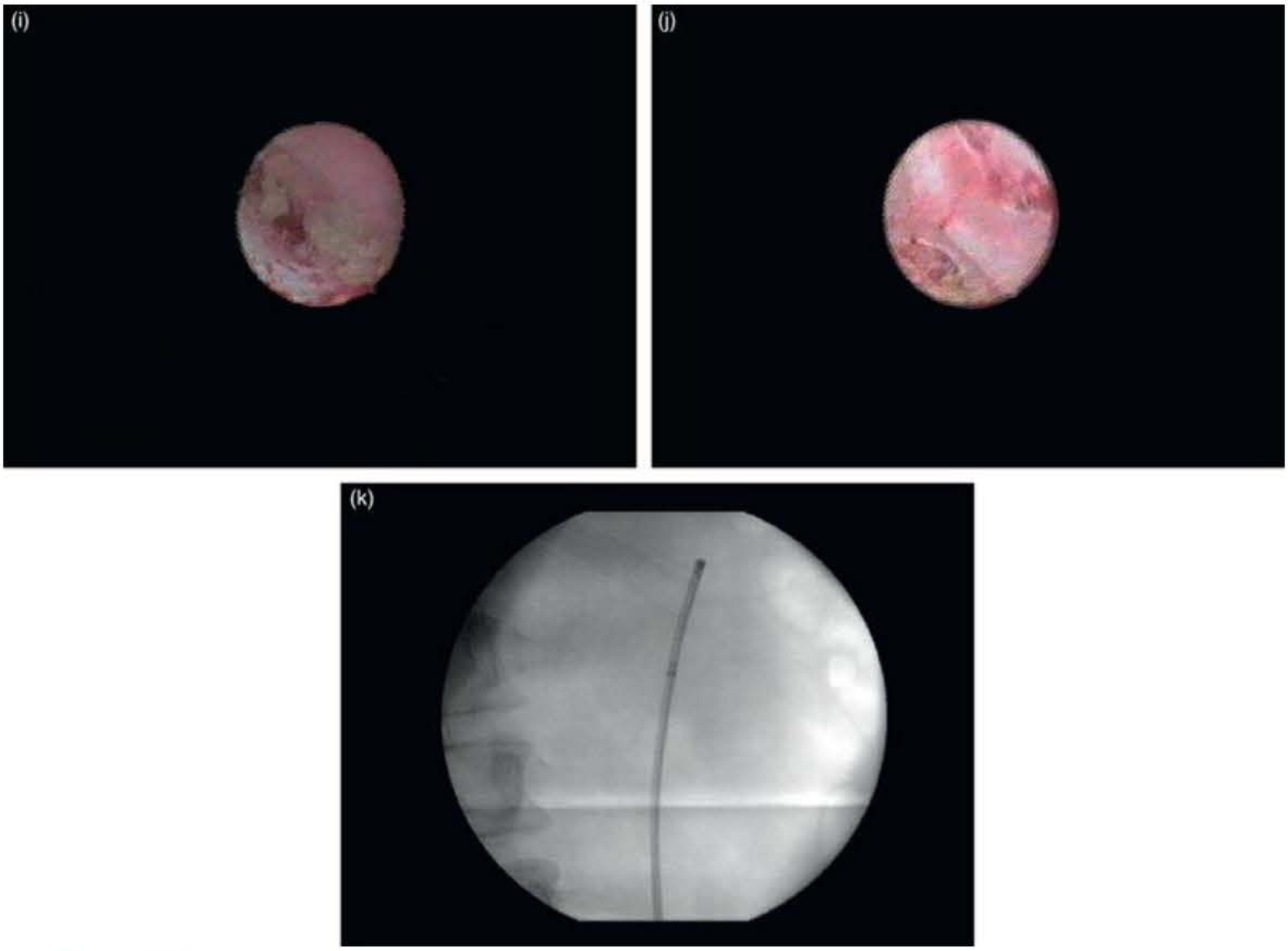
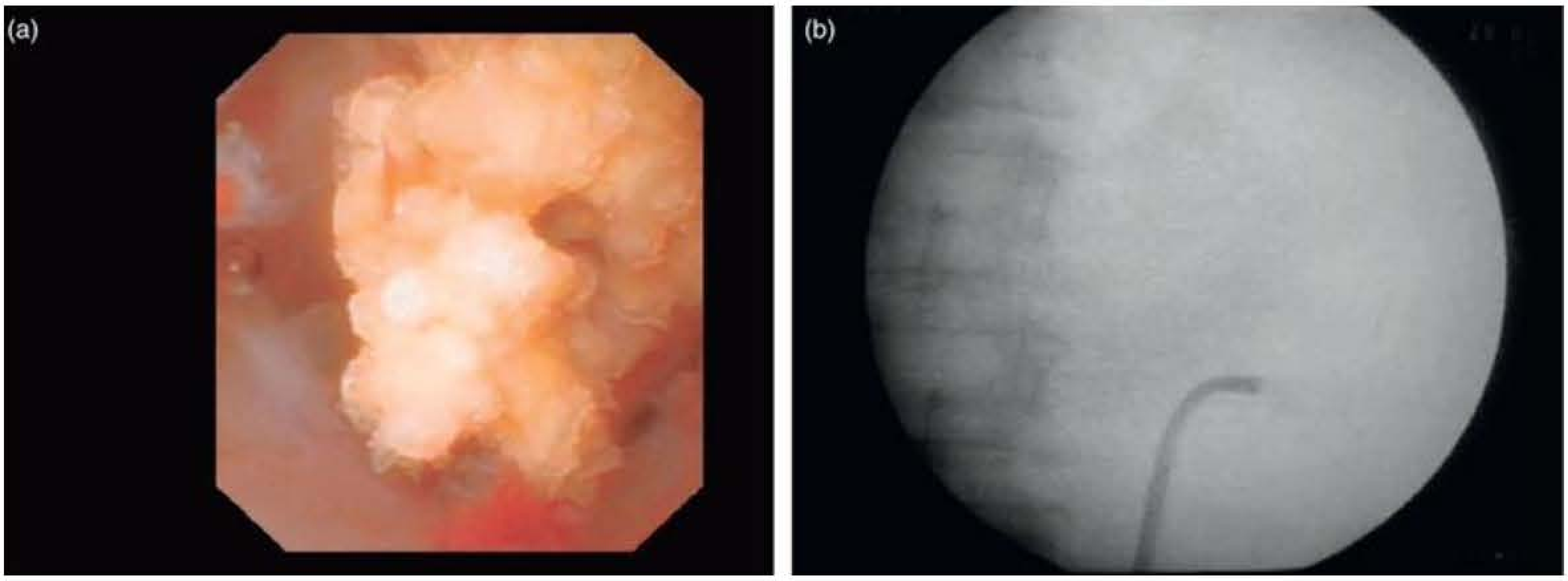


Figure 6.66 **Left pyelic stone (a, b) for which *in situ* electrohydraulic lithotripsy is performed (c, d), with migration of the fragments into the upper calyx and completing fragmentation at this level (e–k).**

For laser lithotripsy (Fig. 6.67), 200–365 µm fibers will be used through the flexible ureteroscope. The laser fiber must not be advanced when the flexible ureteroscope is flexed due to the risk of perforation of the working channel. For the lithotripsy of pyelocaliceal calculi, the initial settings are represented by a power of 1 J and a pulse frequency of 10 Hz. In case of large lithiasic fragments or when lithotripsy seems inefficient, a power of 1.5 J at a pulse frequency of 15 Hz can be used (Knudsen and Denstedt, 2007).



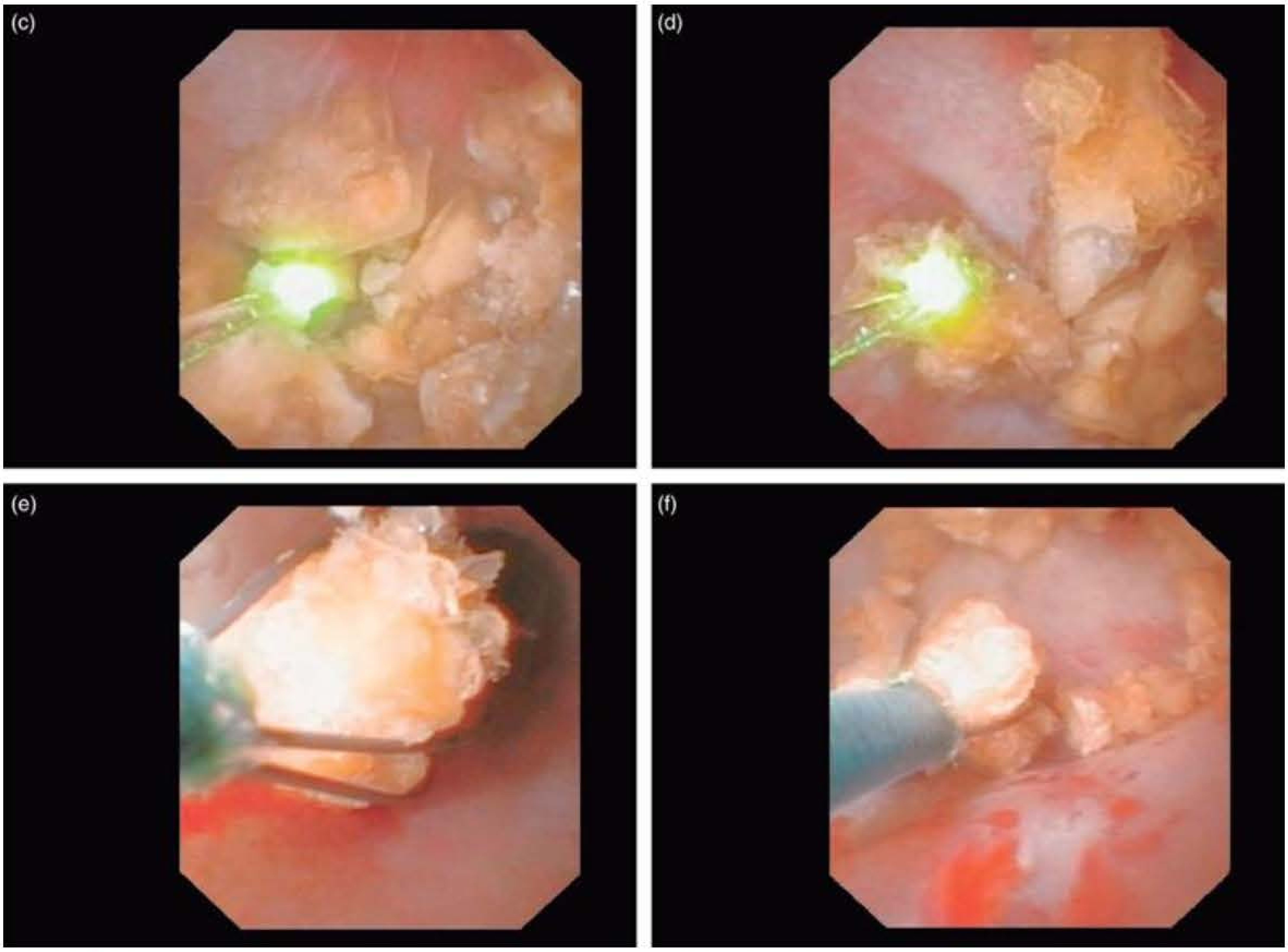


Figure 6.67 Lower caliceal stone (a), fragmented by Ho:YAG laser (b–d), and extraction of the larger fragments with the basket catheter (e, f).

Hybrid techniques for simultaneous retrograde and flexible percutaneous approach have also been described (Fig. 6.68), especially in the case of large, coraliform lithiasis.

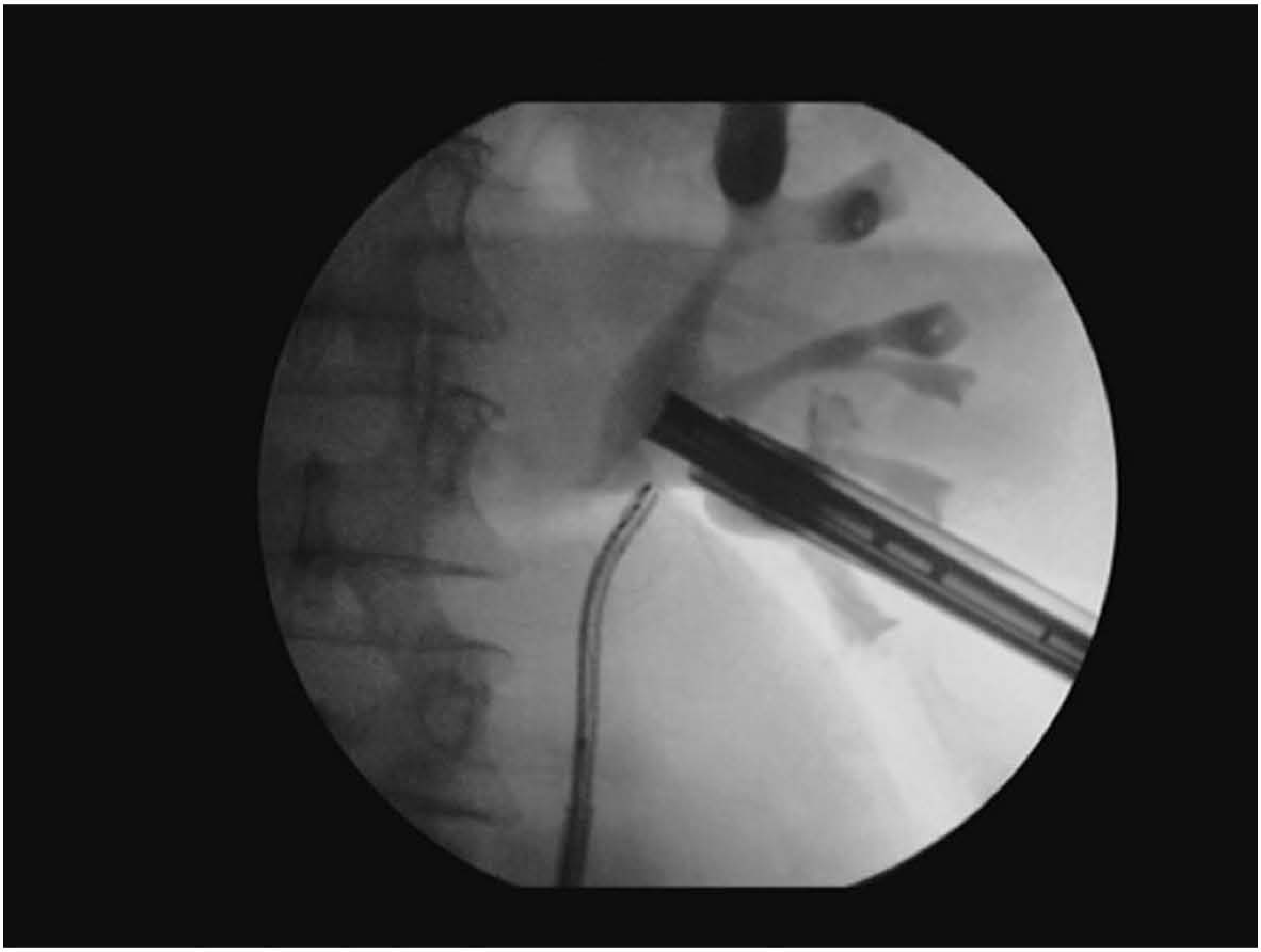


Figure 6.68 **Combined flexible and percutaneous ureteroscopic approach.**

The combined use of the two methods would allow for performing the intervention by using a single percutaneous path, with the extraction of larger lithiasic fragments than is possible by transureteral approach and limiting the number of excursions of the flexible ureteroscope (Undre et al., 2004). Grasso and coworkers describe a combined retro- and antegrade technique for patients with complex renal lithiasis in which punction of the collecting system is performed by flexible ureteroscopy under direct visual control (Fig. 6.69), the calculi subsequently being extracted percutaneously (Grasso et al., 1995b).

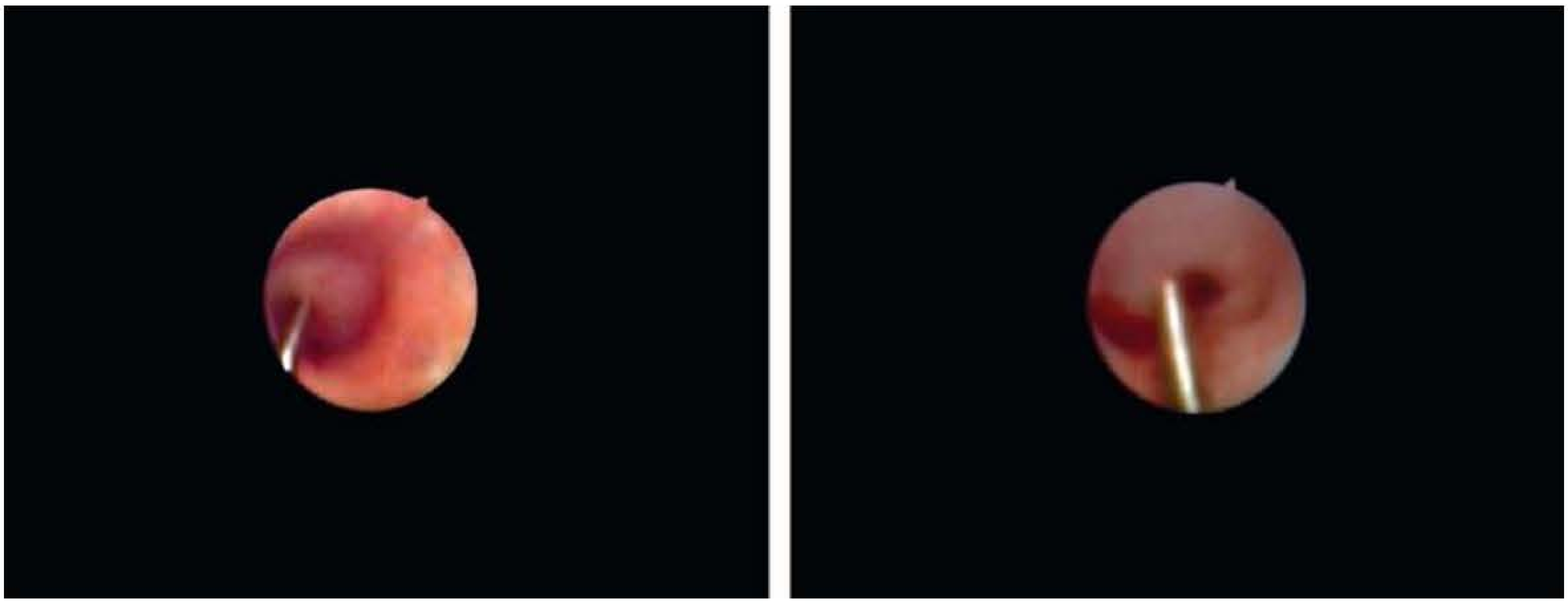
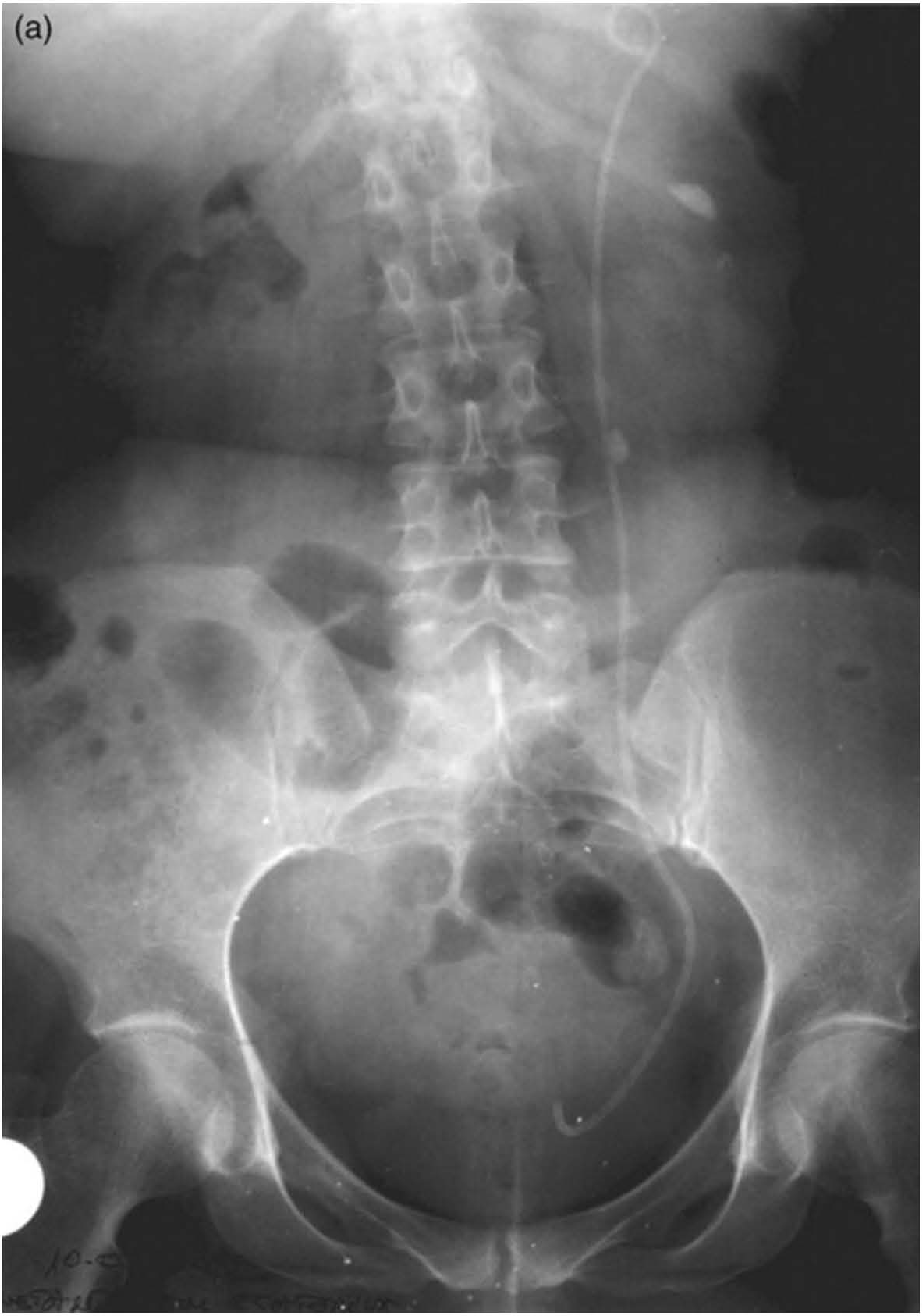


Figure 6.69 **Percutaneous puncture of a calyx by flexible ureteroscopy under direct visual control.**

In case of multiple reno-ureteral lithiasis, the accessible calculi will be approached with rigid or semirigid endoscopes (Fig. 6.70), while the others are treated by flexible approach (Fig. 6.71).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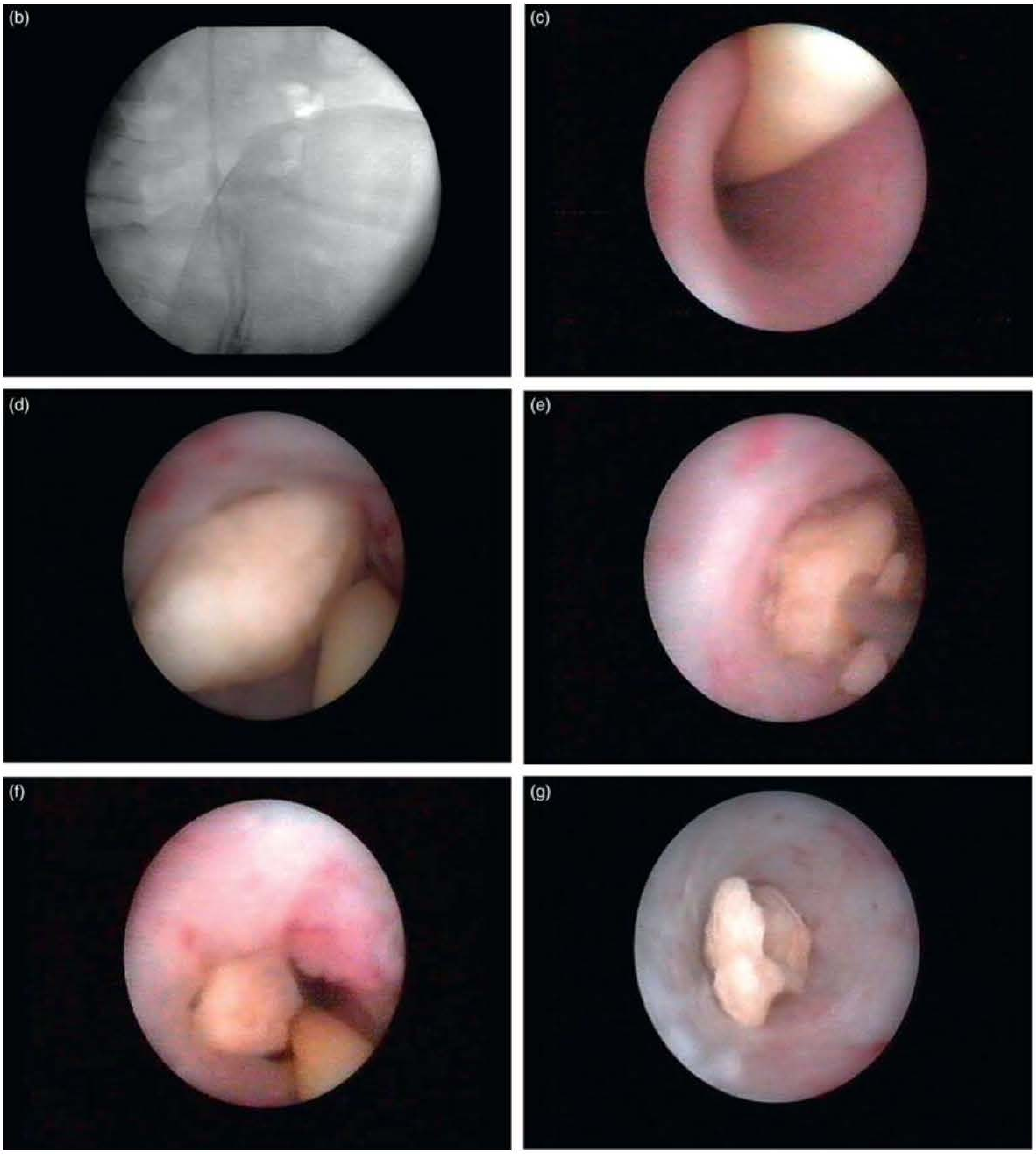
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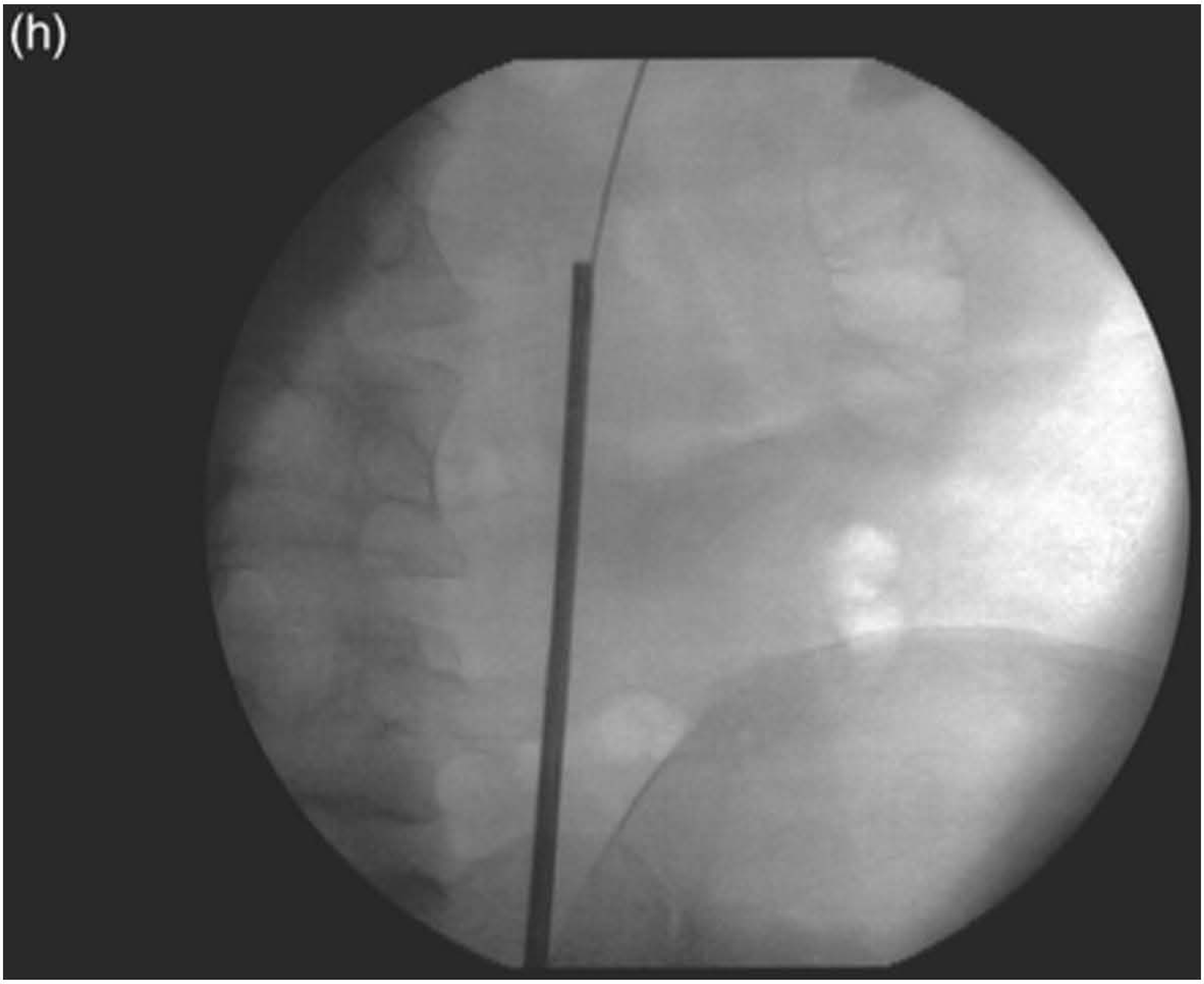
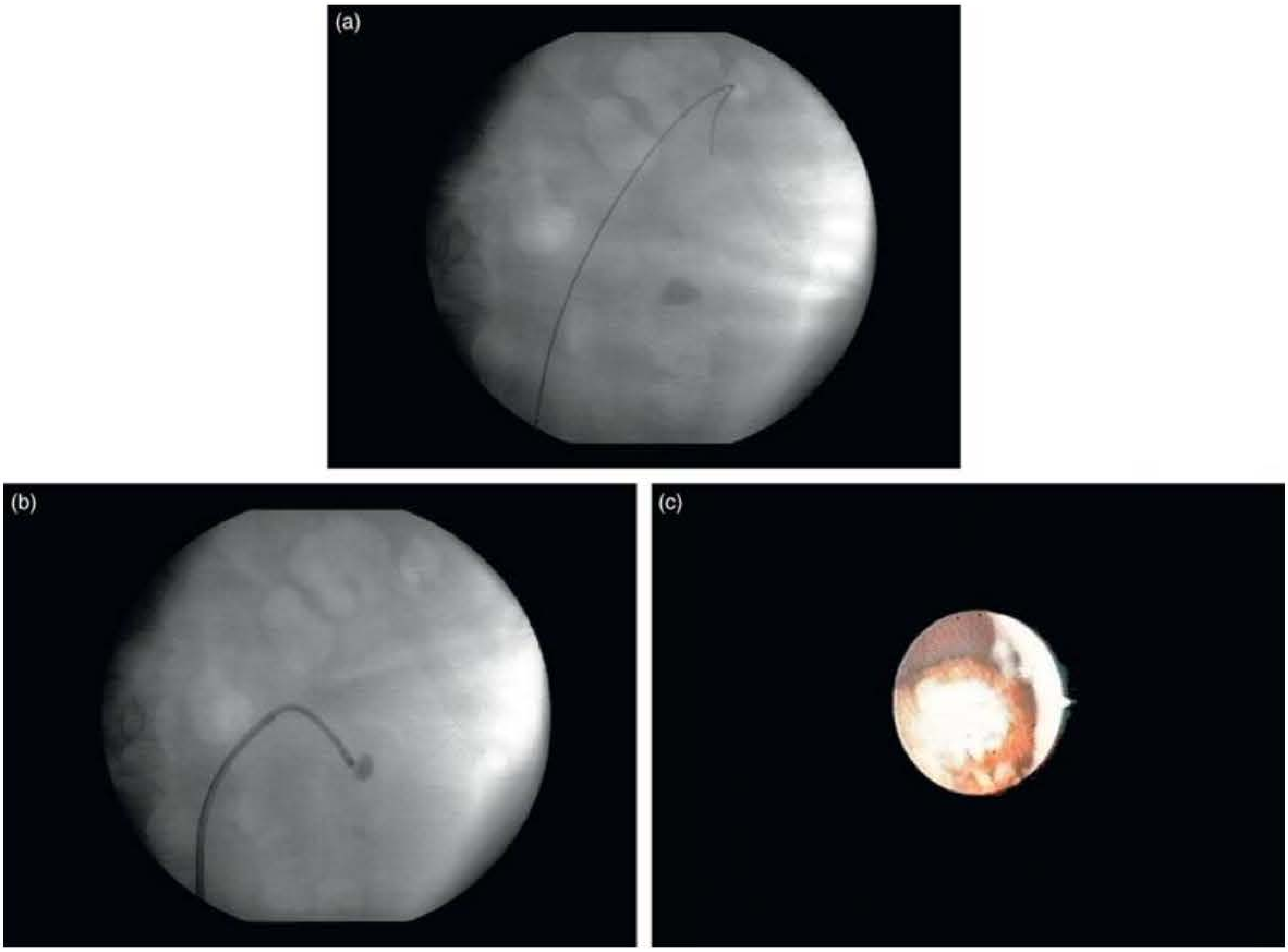


Figure 6.70 Semirigid ureteroscopic approach, alongside the fixed JJ stent, of the ureteral stone in a patient with multiple ureteral and lower caliceal lithiasis (a–d): ballistic lithotripsy of the stone (e–g), and stone-free aspect of the ureter (h).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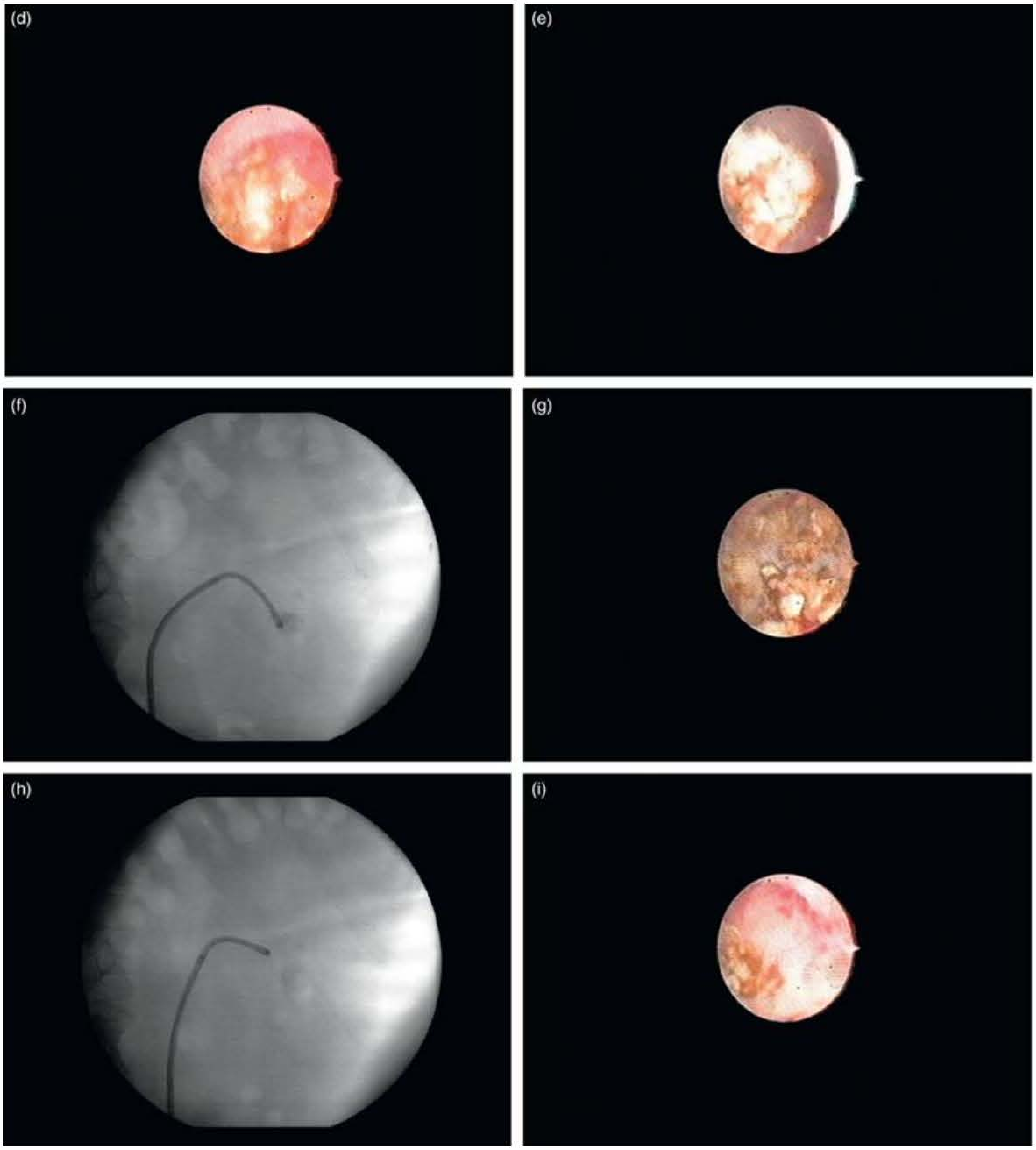
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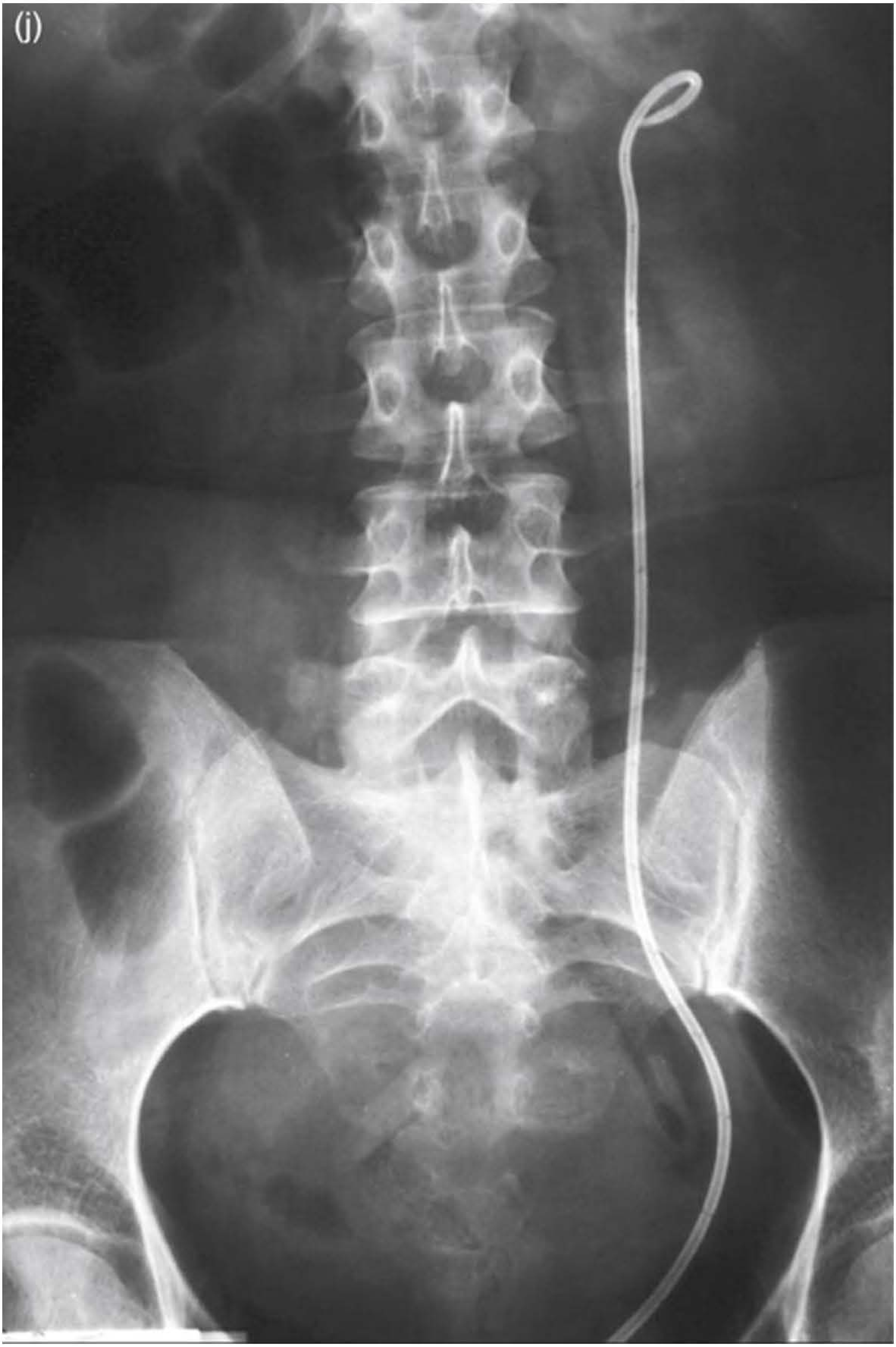

Figure 6.71 Flexible ureteroscopic approach of the lower caliceal stone (a–c), with electrohydraulic lithotripsy of the stone (d–i), and stone-free aspect at the end of the intervention, with a correctly positioned JJ stent (j).

6.4.7. Ureteral Stenting

Postinterventional stenting is not routinely performed in patients in whom flexible ureteroscopes with a diameter under 9 F were used and if dilation of the intramural ureter was not necessary.

In cases where stenting is required (after balloon catheter dilation of the intramural ureter, after prolonged interventions, etc.), the procedure ends by ascending a JJ ureteral stent on the metallic guidewire, under fluoroscopic control.

A ureterovesical catheter is placed for 12–24 h.

6.5. The results of retrograde ureteroscopy in the treatment of upper urinary tract lithiasis

The technological advances regarding endoscopic equipment, the introduction of small-caliber semirigid ureteroscopes, and of flexible ones, combined with the use of the Ho:YAG laser have improved the stone-free rate after ureteroscopy associated with a reduction in the risk of complications. In a comparative study regarding the efficacy of electrohydraulic versus Ho:YAG lithotripsy, Teichman et al. (1998) observed stone-free rates of 65% versus 97%, while the stone-free rates in cases of large calculi were 33% versus 87%.

Although with a higher degree of invasiveness compared to extracorporeal lithotripsy, ureteroscopy using small-caliber instruments is the most efficient technique for treating ureteral calculi.

The results of the ureteroscopic approach of ureteral lithiasis depend on multiple factors that include location, dimensions, chemical composition, and duration of impaction of the stones, the type of lithotripsy used, and the status of the overlying urinary tract.

The location of the calculi significantly influences the results of the retrograde ureteroscopic approach of ureteral lithiasis and the indications for this type of therapy.

The efficacy of retrograde ureteroscopy in the treatment of proximal ureteral calculi (Fig. 6.72) has been the subject of many studies that have reported stone-free rates after one procedure ranging from 75% to 97% (Grasso et al., 1995a, 1998; Tawfiek and Bagley, 1999).

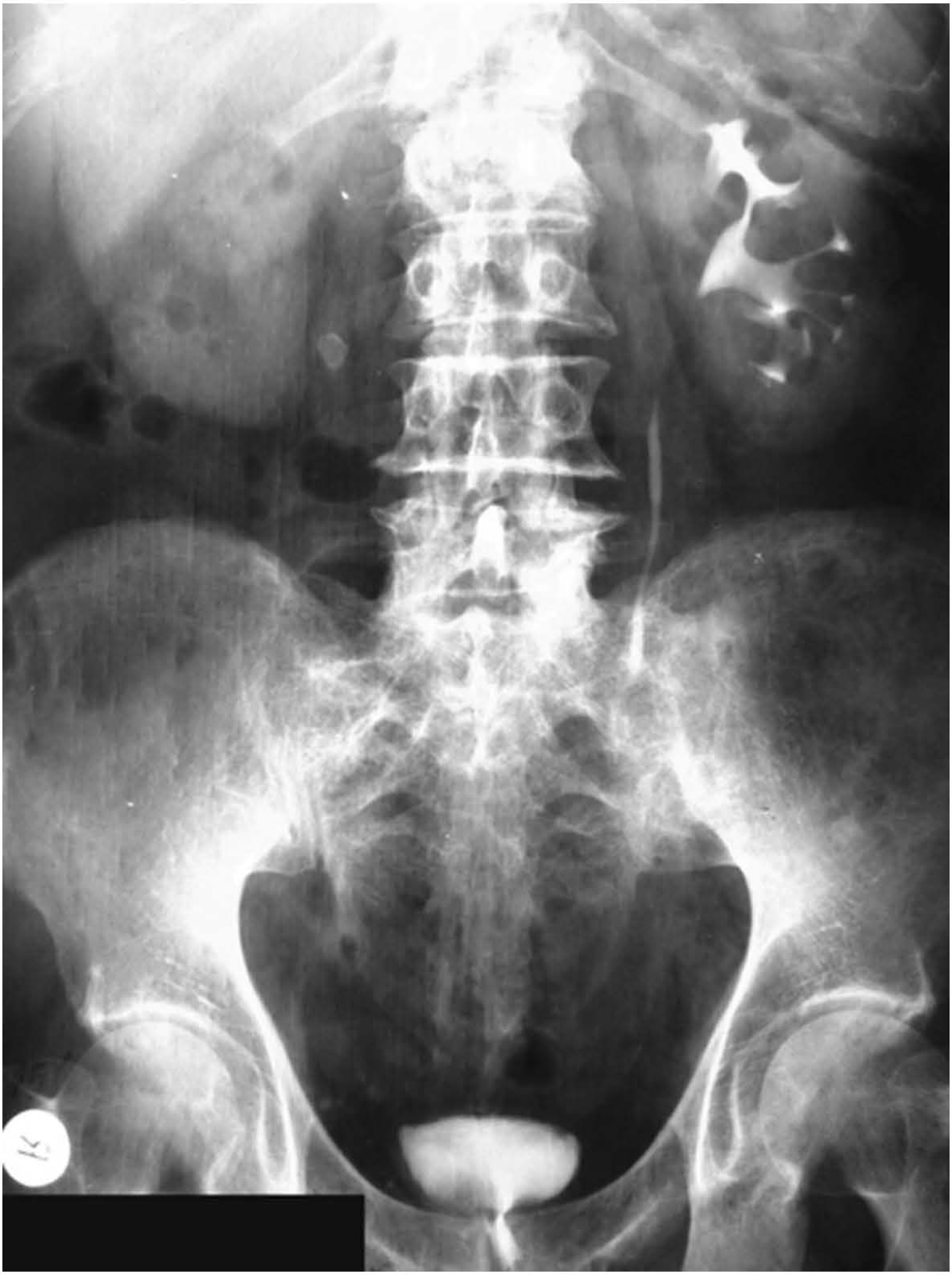
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Figure 6.72 Right lumbar ureteral stone (intravenous urography).

According to the AUA guideline, SWL *in situ* or after retrograde manipulation of the stone represents the first therapeutic alternative for proximal ureteral calculi smaller than 1 cm. After the publication of the AUA guideline, significant progress was made regarding the development of small-caliber flexible ureteroscopes and of lithotripsy devices, with the introduction into current practice of 6.9–7.5 F ureteroscopes with 3.6 F working channels, which allow for a much easier access to the stone.

Moreover, Ho:YAG lithotripsy has allowed for the treatment of calculi regardless of their chemical composition. The published data have shown very good results for this type of lithotripsy during ureteroscopy for proximal and distal ureteral stones, with a stone-free rate of 95%, associated with a risk of perforation or ureteral stenosis of 1%. These results are similar or superior to those obtained by extracorporeal lithotripsy.

Despite these advances, some urologists are still in favor of extracorporeal lithotripsy as the first therapeutic alternative for calculi smaller than 1 cm located in the proximal ureter. Flexible ureteroscopy may represent the first therapeutic alternative for cystine stones, impacted ureteral stones, in case of association of a subjacent obstructive cause, in obese patients or those with hemorrhagic diathesis, or after failure of SWL (Tawfiek and Bagley, 1999), or when extracorporeal lithotripsy is not accessible.

Semirigid and flexible ureteroscopy as a first-line therapy for proximal ureteral calculi larger than 1 cm remains a viable option, with an important success rate (Segura et al., 1997).

The results of extracorporeal lithotripsy were compared with those of ureteroscopy in a group of 54 patients with proximal ureteral lithiasis (Grasso et al., 1995a). Of these, 27 benefited from ureteroscopic lithotripsy and 27 from SWL treatment. The mean diameter of the stones was 10 mm in both groups. The stone-free rate 1 month after the ureteroscopy was 95%, reaching 97% at 3 months. A single patient required a second procedure for a residual 4 mm fragment. In the group that benefited from extracorporeal lithotripsy, the stone-free rate at 1 month was only 45%, reaching 62% at 3 months. The costs of the initial therapy were similar, but in the end, extracorporeal lithotripsy incurred costs double those of the endoscopic approach, due to the need for additional procedures.

According to the EAU/AUA Consensus, although the success rates of SWL and ureteroscopy are relatively equal for proximal ureteral calculi (82% and 81%, respectively), there are differences depending on the dimensions of the lithiasis. For calculi smaller than 10 mm, SWL presents higher success rates (90% vs. 80%); for larger stones, ureteroscopy is the more efficient method (79% vs. 68%) (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

For distal ureteral calculi (Fig. 6.73), retrograde ureteroscopy has an efficacy similar to that of SWL, both being first-line therapeutic alternatives (Segura et al., 1997). They have a high success rate, with a reduced morbidity, so that choosing the interventional treatment for distal ureteral calculi remains a controversial subject of modern urology.

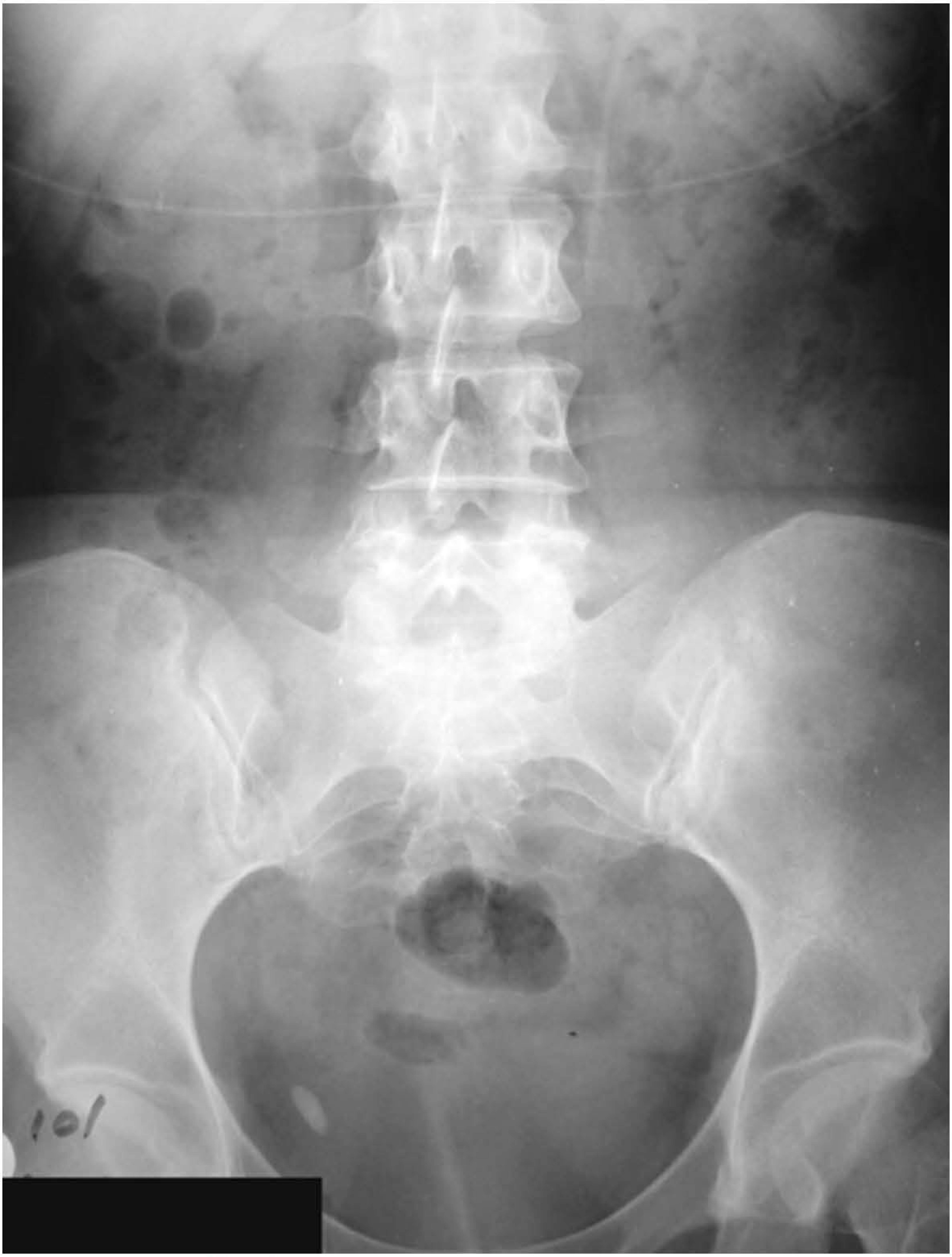

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Figure 6.73 **Right distal ureteral stone (intravenous urography).**

Ureteroscopy ensures a high stone-free rate after a single procedure, associated with a reduced rate of iterative procedures.

The published data have shown a mean stone-free rate of 94% (86.4–100%) after ureteroscopy, the retreatment rate being 8% (0.8–19.8%), while after SWL these were 81% (50–99%) and 27% (7.1–50%), respectively (Bierkens et al., 1998; Kupeli et al., 1998; Park et al., 1998; Pardalidis et al., 1999; Peschel et al., 1999; Turk and Jenkins, 1999).

Many authors have demonstrated that extracorporeal lithotripsy has an efficacy similar to that of retrograde ureteroscopy for small calculi (under 1 cm), but this decreases significantly in patients with large stones. These authors recommend extracorporeal lithotripsy for small, single calculi, while ureteroscopy is indicated in large or multiple calculi (Fig. 6.74) (Eden et al., 1998; Park et al., 1998; Pardalidis et al., 1999). Two prospective studies regarding the treatment of distal ureteral calculi by extracorporeal lithotripsy or retrograde ureteroscopy led to contradictory results. Pearle et al. (1998) assessed a group of 40 patients with distal ureteral calculi (under 8 mm) who underwent SWL or retrograde ureteroscopy. After a 3-month follow-up period, the stone-free rate was 100% with a minimal morbidity. The degree of patient satisfaction was relatively higher for those treated by SWL (96.2%) compared to those treated by retrograde ureteroscopy (86.5%).

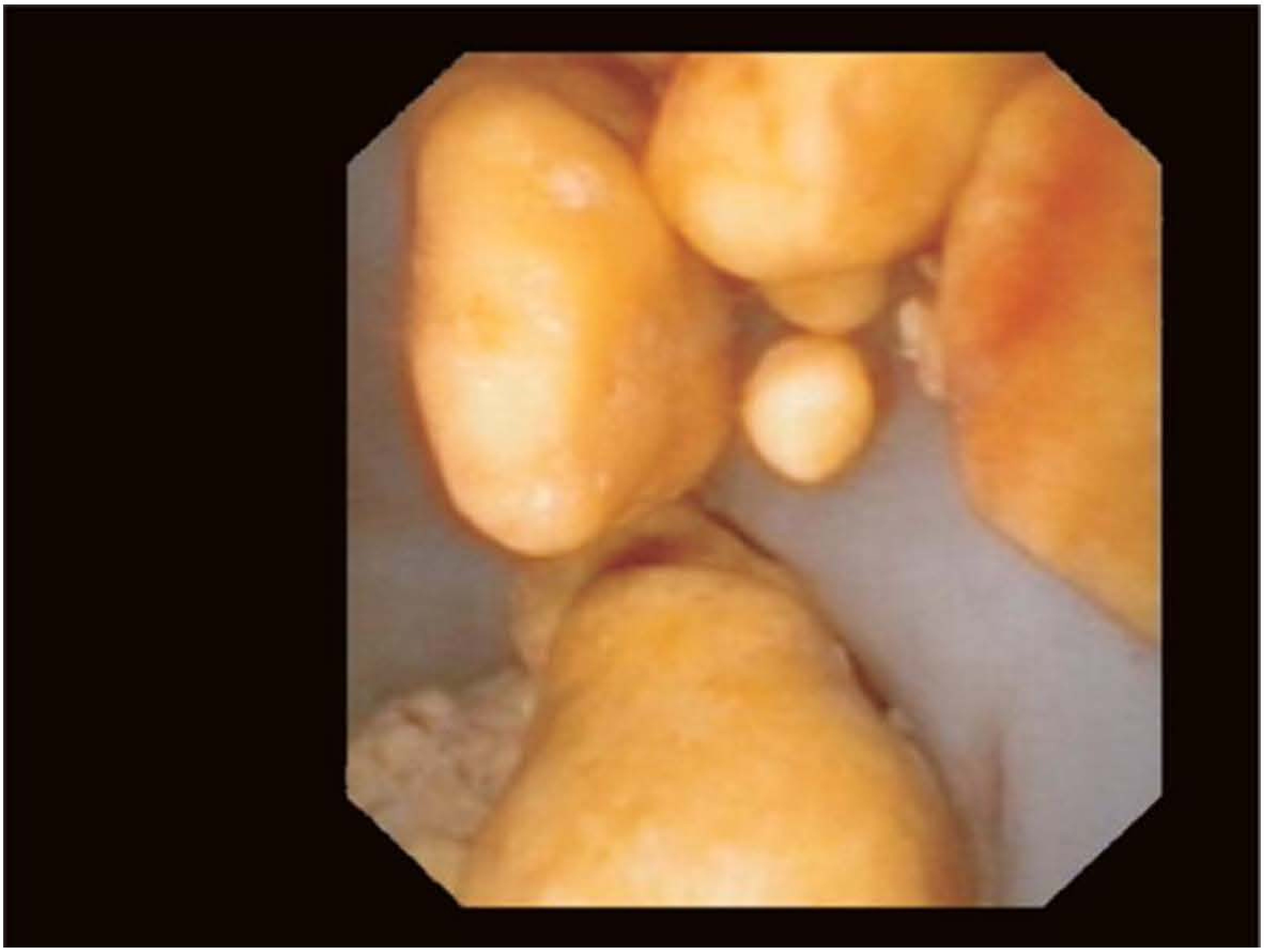


Figure 6.74 **Multiple ureteral lithiasis.**

Peschel et al. (1999) assessed 80 patients with distal ureteral calculi classified according to their dimensions (under and over 5 mm) and randomized between the two therapeutic alternatives. Ureteroscopy was superior regarding duration of intervention, exposure time to radiation, and duration until the complete elimination of the calculi. All patients were stone free at the end of the follow-up period. The retreatment rate in patients who underwent SWL was 15% for calculi over 5 mm and 10% for calculi under 5 mm. Multiple procedures were not necessary in cases of ureteroscopic approach. All patients who underwent retrograde ureteroscopy declared that they were satisfied with the success of the procedure. Twenty-five percent of patients in whom extracorporeal lithotripsy was performed for calculi smaller than 5 mm and who required retreatment or in whom the lithiasic fragments were eliminated only after 6 weeks would have chosen ureteroscopy in case of recurrences. Also, calculi under 5 mm that were not eliminated spontaneously after 3 weeks were treated more efficiently by ureteroscopy (Fig. 6.75), being more difficult to detect during SWL (Van Cangh, 1999).

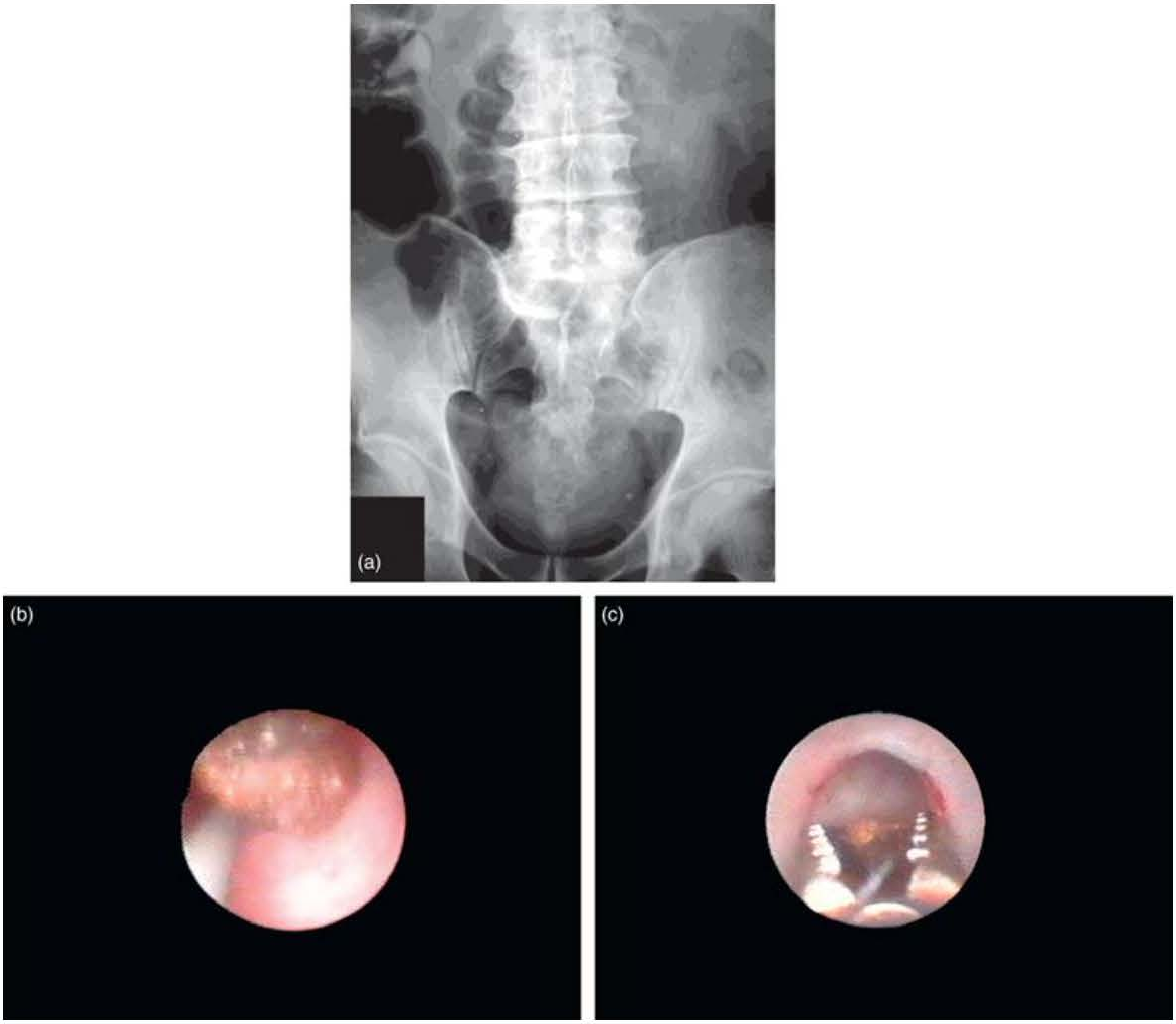


Figure 6.75 **Small left pelvic ureteral stone (a, b), ureteroscopically extracted with a clamp (c).**

The published data suggest a shift of options from SWL toward ureteroscopy due to its technological advances and to the increasing experience of operators (Clayman, 1999). However, ample randomized studies are required in order to clearly assess the optimal therapeutic alternative for distal ureteral calculi. In the current stage, the patients must be offered the opportunity of choosing, in an informed manner, between SWL and ureteroscopy. Moreover, the cost-efficiency ratio, the operator's experience, and the technical endowment must be taken into account when choosing the therapeutic alternative.

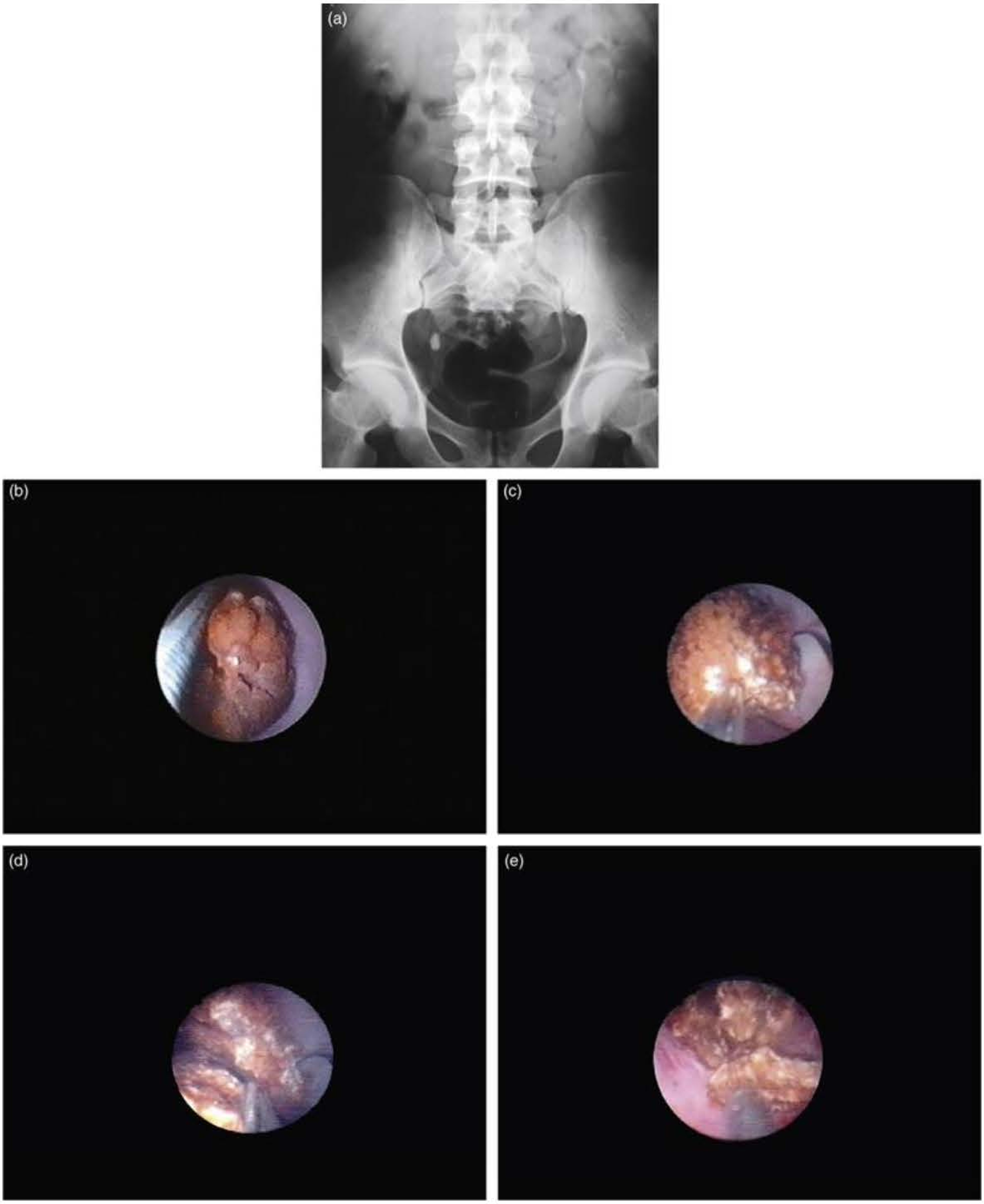
The meta-analyses performed during the drafting of the 2007 EAU/AUA Consensus show a higher success rate in cases of ureteroscopy compared to SWL for distal ureteral calculi (94% vs. 74%) or middle ureteral calculi (86% vs. 73%), with the mention that for the latter, the relatively low number of cases may affect the statistical significance of the data (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

An important role in assessing the efficacy of a therapeutic alternative is played by the complete elimination of fragments. From the patient's point of view, this represents an essential element in choosing the therapeutic modality. In this setting, ureteroscopic fragmentation and extraction of the calculi determines a significant increase of the stone-free rate after a procedure. Teichman et al. (1998) observed that all types of lithotripsy, with the exception of Ho:YAG lithotripsy, determine the appearance of fragments larger than 4 mm.

These relatively small lithiasic pieces are difficult to fragment using the ballistic lithotripter, especially in cases of tough calculi, with a dilated suprajacent urinary tract. The residual fragments larger than 4 mm are associated with an increased rate of iterative procedures, and for this reason they must be extracted during the initial procedure (Keeley et al., 1999).

Another important element for the results of the procedure and for establishing the diagnosis is the dimensions of the stones.

The experience gained regarding the different therapeutic alternatives has demonstrated their different efficacy for large ureteral calculi. While SWL determines a stone-free rate ranging from 76% to 82% (Ueno et al., 1977; Drach et al., 1986), with an increased probability of requiring multiple sessions, especially for calculi with an area of over 50 mm² (Mattelaer et al., 1994; Bierkens et al., 1998), ureteroscopy, especially the flexible one, determines a success rate between 90% and 97% (Erhard et al., 1996; Grasso and Bagley, 1996). The results of this method are less influenced by the dimensions and location of the lithiasis than extracorporeal lithiasis, being more efficient for large ureteral calculi. The efficacy of SWL is also reduced in cases with very small calculi, due to the difficulties in locating them radiologically. Fortunately, these calculi are usually eliminated spontaneously (Bierkens et al., 1998). Park et al. (1998) compared the results of SWL and of retrograde ureteroscopy for ureteral calculi, proving that while the efficacy of SWL decreases significantly for calculi larger than 1 cm (83.6% vs. 42.1%), the success rate of retrograde ureteroscopy was not affected by the dimensions of the calculi (88.9% vs. 86.6%) (Fig. 6.76).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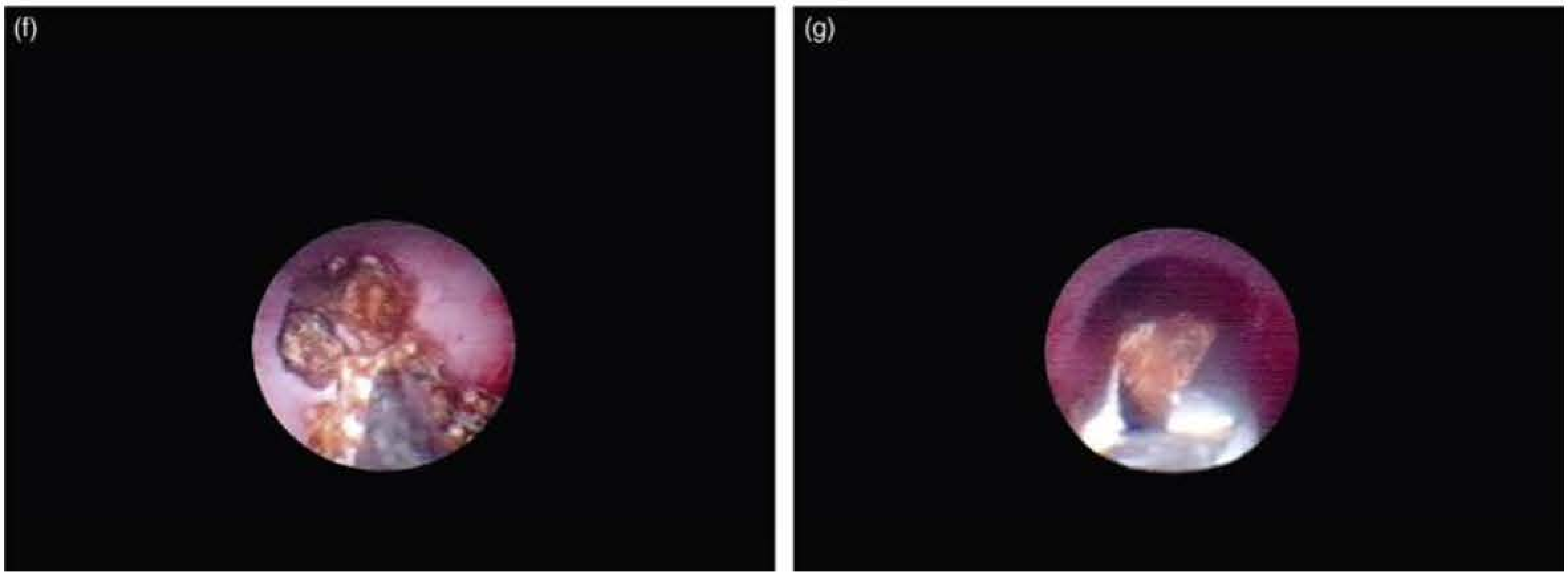


Figure 6.76 Ureteroscopic approach of a large right ureteral stone (a, b): ballistic lithotripsy of the stone fixed in the basket catheter (c–f), extraction of the fragments with a clamp (g).

In instances with stones smaller than 1 cm, the stone-free rate after SWL and ureteroscopy was 84% and 56%, respectively, while for calculi larger than 1 cm, it was 72% and 44%, respectively. The risk of significant complications after SWL and ureteroscopy was 4% and 11%. Although open surgical ureterolithotomy determined a mean stone-free rate of 97%, it was associated with a prolonged hospitalization period and an increased morbidity, and therefore cannot be considered as a first-line treatment.

Frequently, the failure of the procedure is determined by the impossibility of fixing the stone, in case of important dilation of the suprajacent urinary tract (Denstedt et al., 1991). The rate of ascendant migration depends on the initial localization of the stone, being clearly higher for proximal ureteral stones compared to the distal ones (Knispel et al., 1998).

Due to the higher success rate compared to the alternatives, ureteroscopy has been recommended as the first-line treatment of impacted ureteral calculi (Fig. 6.77).

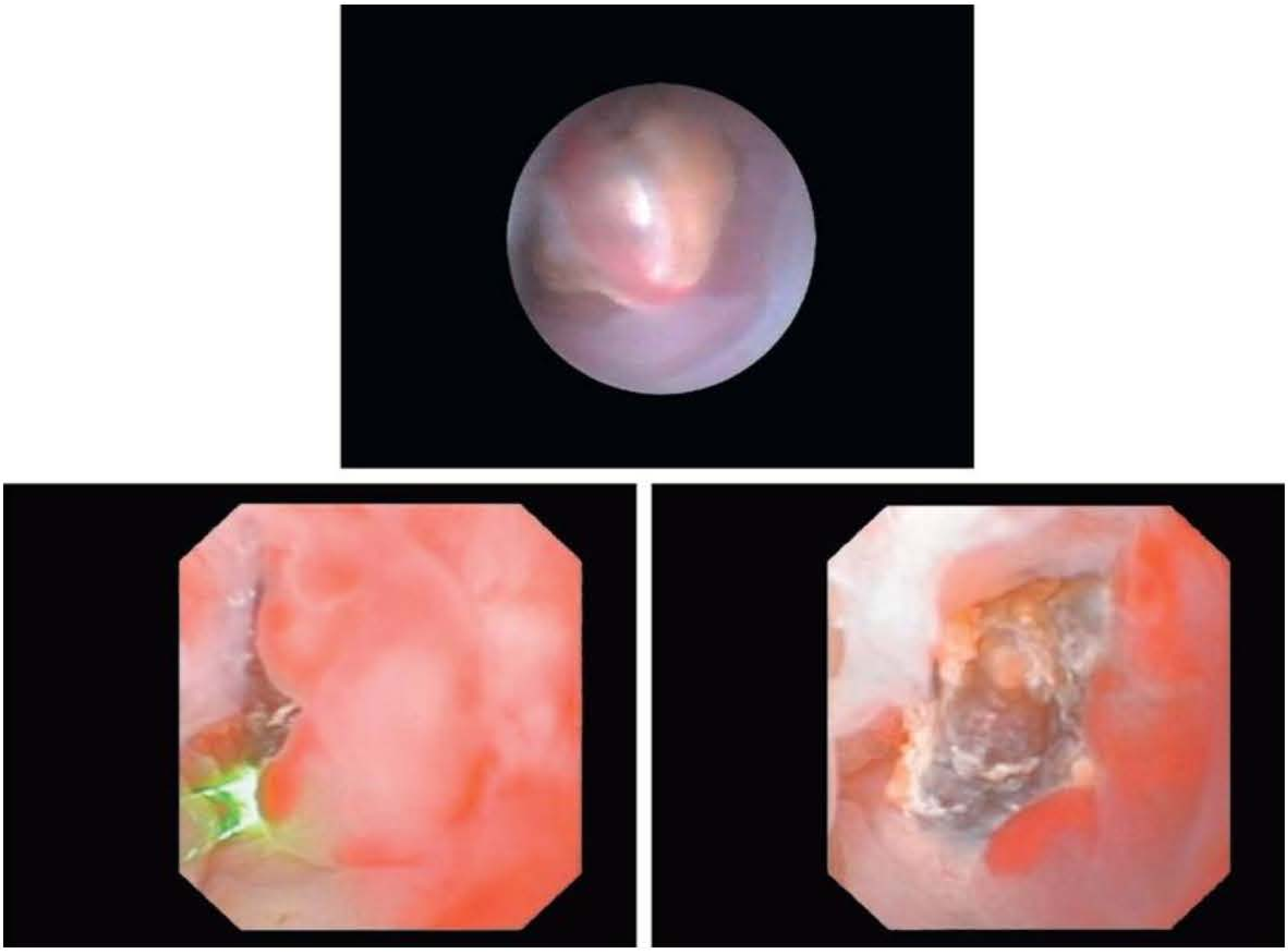


Figure 6.77 **Impacted ureteral calculi.**

Mugiya et al. (2000) demonstrated the efficiency of flexible ureteroscopy (6.9–7.5 F) associated with Ho:YAG laser lithotripsy in a group of 104 patients with impacted ureteral calculi, in 83 cases the stones being located in the proximal ureter. Complete fragmentation of the stone after a single procedure was obtained in 96.2% of cases, and the stone-free rate at 1 month was 100%, without significant complications. Yagisawa et al. (2000) compared the results of SWL and ureteroscopy with ballistic lithotripsy for impacted ureteral calculi. While the stone-free rate at 1 month after ureteroscopy was 100%, all patients initially treated by SWL required auxiliary endoscopic manipulation.

The retrograde flexible ureteroscopic approach of ureteral calculi must be seen as a method that is complementary to rigid ureteroscopy; when the latter cannot be performed, it is contraindicated, or inefficient.

The initial results of using flexible ureteroscopes were not superior to those obtained by SWL, both determining stone-free rates of approximately 80% (Drach et al., 1986; Bagley, 1990; Frang et al., 1992; Mogensen and Andersen, 1994). However, by using small-caliber ureteroscopes associated with the use of the Ho:YAG laser, the success rate after one procedure increased to 97% (Grasso and Bagley, 1996).

The success rate for combined retrograde approach (semirigid and flexible) in ureteral lithiasis ranges between 71.4% and 99% (Table 6.2).

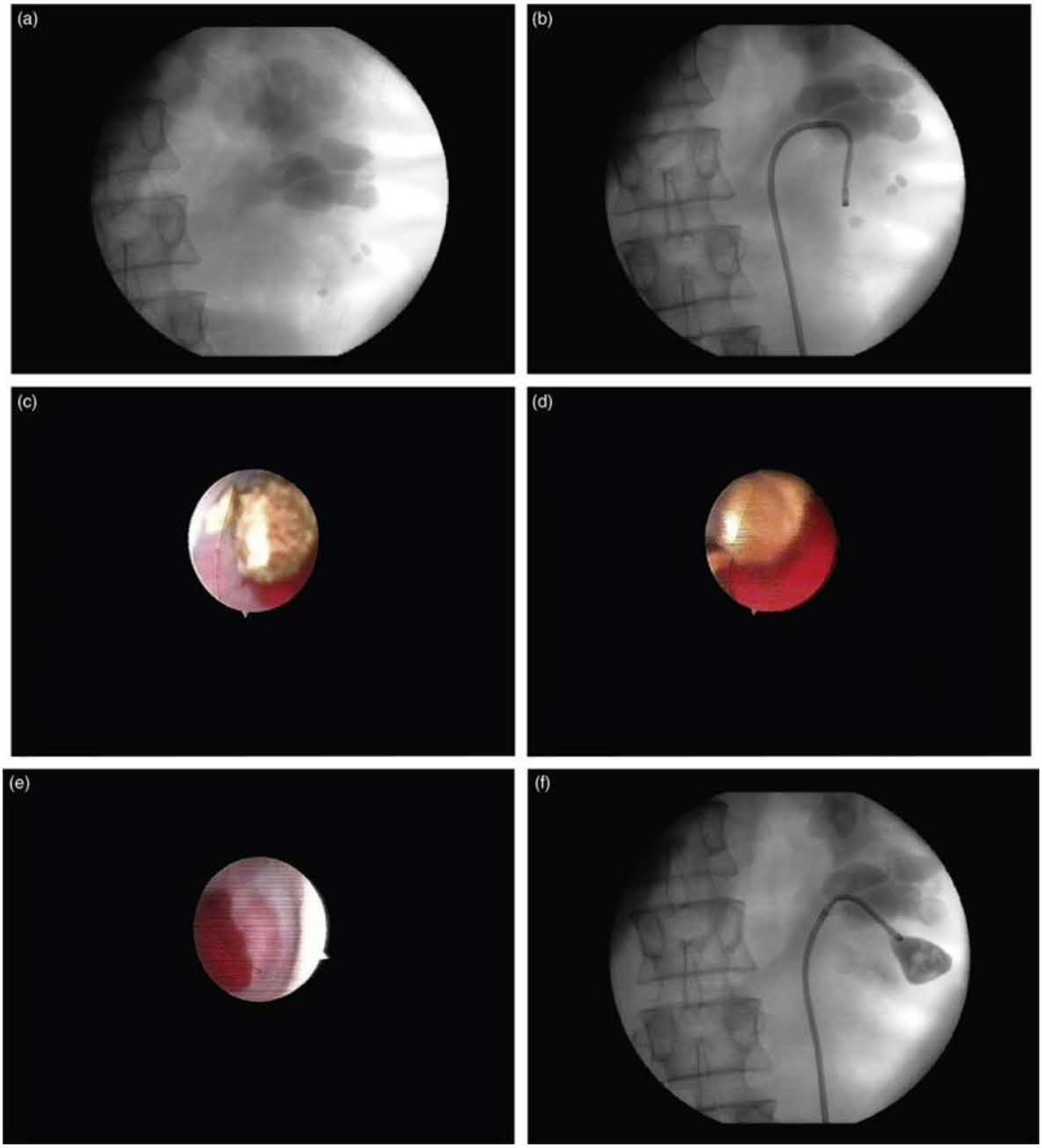
Table 6.2

The Results of Combined (Semirigid and Flexible) Retrograde Ureteroscopic Approach in Ureteral Lithiasis

Authors	No. of patients	Success rate	Success rate (proximal ureter)	Success rate (distal ureter)
Bierkens et al. (1998)	105	–	96	99
Tawfiek and Bagley (1999)	82	98.8	–	–
Lechevallier et al. (1999)	21	71.4	–	–
Mugiya (2000)	104	96.2	–	–
Hollenbeck et al. (2001)	184	–	88	99
Pardalidis et al. (2006)	98	–	–	97.9
Krambeck et al. (2006)	556	91.7	87.3	94.2
Farkas et al. (2006)	131	–	84.6	94.8
Karlsen et al. (2007)	38	78	–	–

Regarding renal lithiasis, although SWL has been the elective method in the treatment of pyelocaliceal calculi smaller than 20 mm, the success rate reaching 92% in selected cases, it can be 53.7–63% for calculi larger than 20 mm (Tiselius at al., 2001; Lingeman et al., 2002), or even only 41% for lower caliceal lithiasis (Stav et al., 2003). In all these cases of extracorporeal lithotripsy failure, it is necessary to use an intracorporeal alternative for fragmenting and/or extracting the calculi. Although with good results in this direction (the stone-free rate being higher than 90%), percutaneous nephrolithotomy remains an invasive method, with significant associated morbidity (Kerbl et al., 2002).

Theoretically allowing for access to any level of the upper urinary tract by using the anatomic pathways, flexible ureteroscopy represents a valuable alternative in the therapeutic arsenal dedicated to renal lithiasis, regardless of its localization (Fig. 6.78) (Geavlete et al., 2007b).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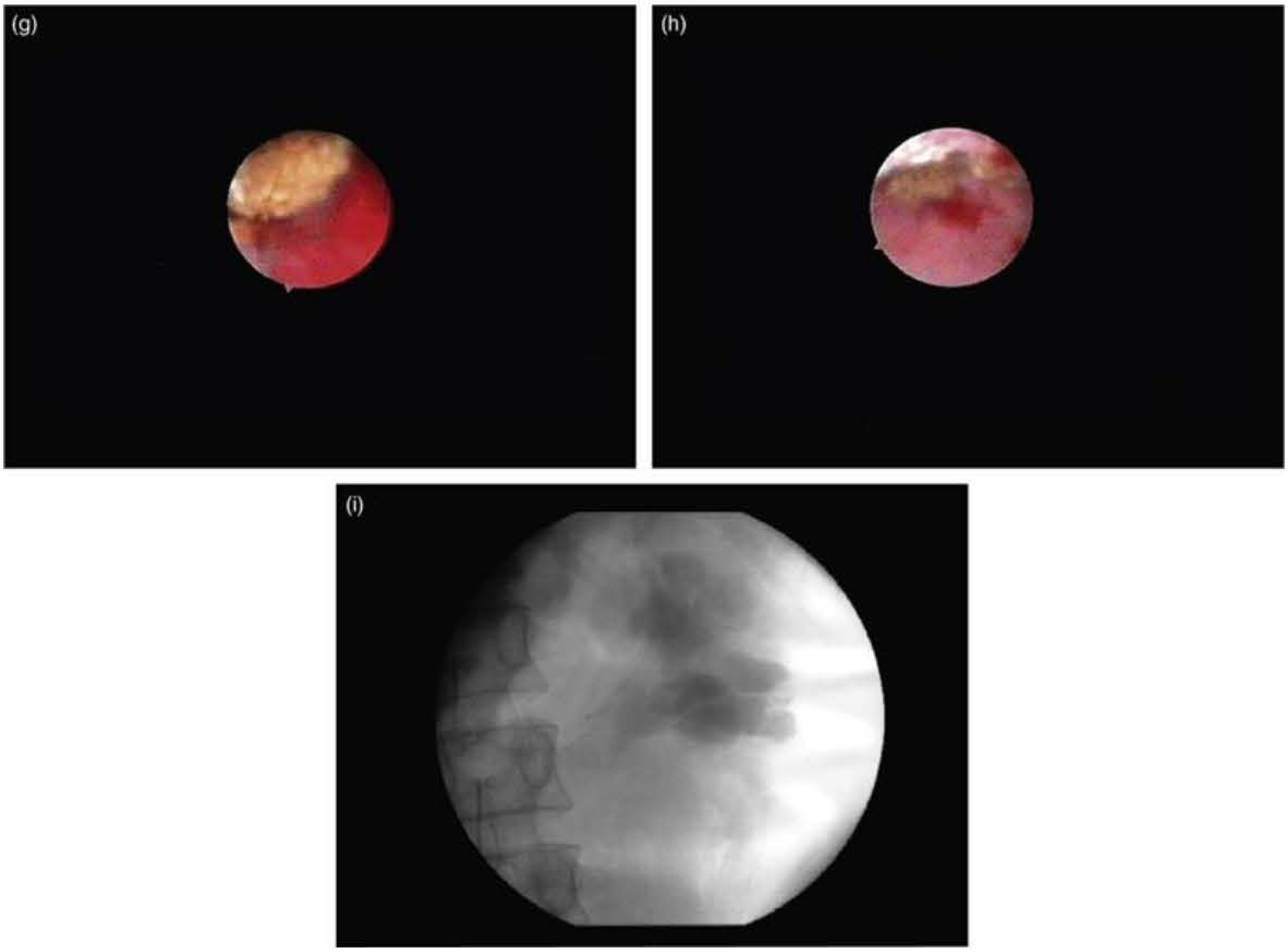


Figure 6.78 **Flexible ureteroscopic treatment of multiple lower and middle caliceal lithiasis (a): approach of the lower calyx (b, c), electrohydraulic lithotripsy of the lower caliceal stone (d), stone-free aspect of the lower calyx (e, f), electrohydraulic lithotripsy of the middle caliceal calculi (g, h), stone-free aspect at the end of the intervention (i).**

During flexible ureteroscopic interventions, the dilation of the ureteral orifice is not routinely indicated, being performed in only 11–22.5% of cases (Grasso and Bagley, 1996; Elashry et al., 1997; Johnson et al., 2006; Geavlete et al., 2007b).

For pyelocaliceal lithiasis, the success rate of flexible ureteroscopic approach varies between 62% and 98%, with a mean number of procedures between 1.02 and 2.4 (Table 6.3).

Table 6.3

The Results of Flexible Ureteroscopy in the Treatment of Pyelocaliceal Lithiasis

Authors	No. patients	Mean no. procedures	Success rate	Observations
Aso et al. (1990)	34	1.6	88.2	–
Elashry et al. (1997)	–	–	98.3	–
Fabrizio et al. (1998)	100	–	89	One fragment <3 mm
Tawfiek and Bagley (1999)	59	–	79.7	Stone-free
Menezes et al. (2000)	22	–	81.8	Fragments <5 mm
Grasso (2000)	90	–	91	Fragments <2 mm
Kourambas et al. (2000)	36	–	85	Stone-free
Hollenbeck et al.	60	1.1	88	Stone-free

(2001)				
El-Anany et al. (2001)	30	–	77	Fragments <2 mm
Schuster et al. (2002)	78	–	79	Stone-free
Stav et al. (2003)	61	–	67	Fragments <3 mm
Dasgupta et al. (2004)	92	1.1	72.3	Fragments <2 mm
Hafron et al. (2005)	13	–	76.9	Stone-free
Fernandez et al. (2005)	49	1.4	62	Fragments <4 mm
Jung et al. (2006)	38	1.02	76	Fragments <4 mm
Preminger (2006)	NA	–	85	Stone-free
Geavlete et al. (2006a)	56	–	69.6	Fragments <3 mm
Mariani (2007)	17	2.4	88	Stone-free

The differences between the reported success rates are due to multiple factors:

- the definition of the intervention's success
- the modality of patient selection
- the type of lithotripsy used
- the chemical composition of the calculi
- the dimensions of the calculi
- the position of the calculi
- the type of flexible ureteroscope used

There are significant differences between the published studies in defining the success of the intervention, from the complete removal of calculi to their lithotripsy into fragments small enough not to become obstructive during elimination (2–5 mm). Most authors limit the dimensions of the potential residual fragments to a maximum of 3 mm (Table 6.3).

In some studies in which only patients with SWL-resistant lithiasis were selected, the success rate of flexible ureteroscopy was lower, between 62% and 69.7% (Stav et al., 2003; Fernandez et al., 2005; Geavlete et al., 2006b).

One of the explanations for these results is the fact that the anatomical particularities of the intrarenal tracts associated with a reduced success rate for extracorporeal lithotripsy can also make retrograde endoscopic approach more difficult (Hollenbeck et al., 2001; Stav et al., 2003).

Also, calculi with certain chemical compositions (e.g., calcium oxalate monohydrate), associated with a low success rate for SWL, may also be resistant to electrohydraulic lithotripsy (Lingeman et al., 2002; Geavlete et al, 2005b). Menezes et al. (1999) report a success rate of 81.8% in the flexible ureteroscopic approach of calculi refractory to other therapeutic methods. Although lower, the success rates of flexible ureteroscopy in patients with SWL-resistant lithiasis are significant, making it a recommended minimally invasive therapeutic alternative in these cases.

The use of the Ho:YAG laser as a lithotripsy method creates the premises for a higher success rate, proving itself to be efficient regardless of the chemical composition of the calculi (Scarpa et al., 1999; Farkas et al., 2006). Also, the safety profile and photothermal effect allow for the lithotripsy of calculi into very small fragments (Figs 6.79 and 6.80), which pass easily through the ureter without requiring active extraction measures (Teichman et al., 1998).

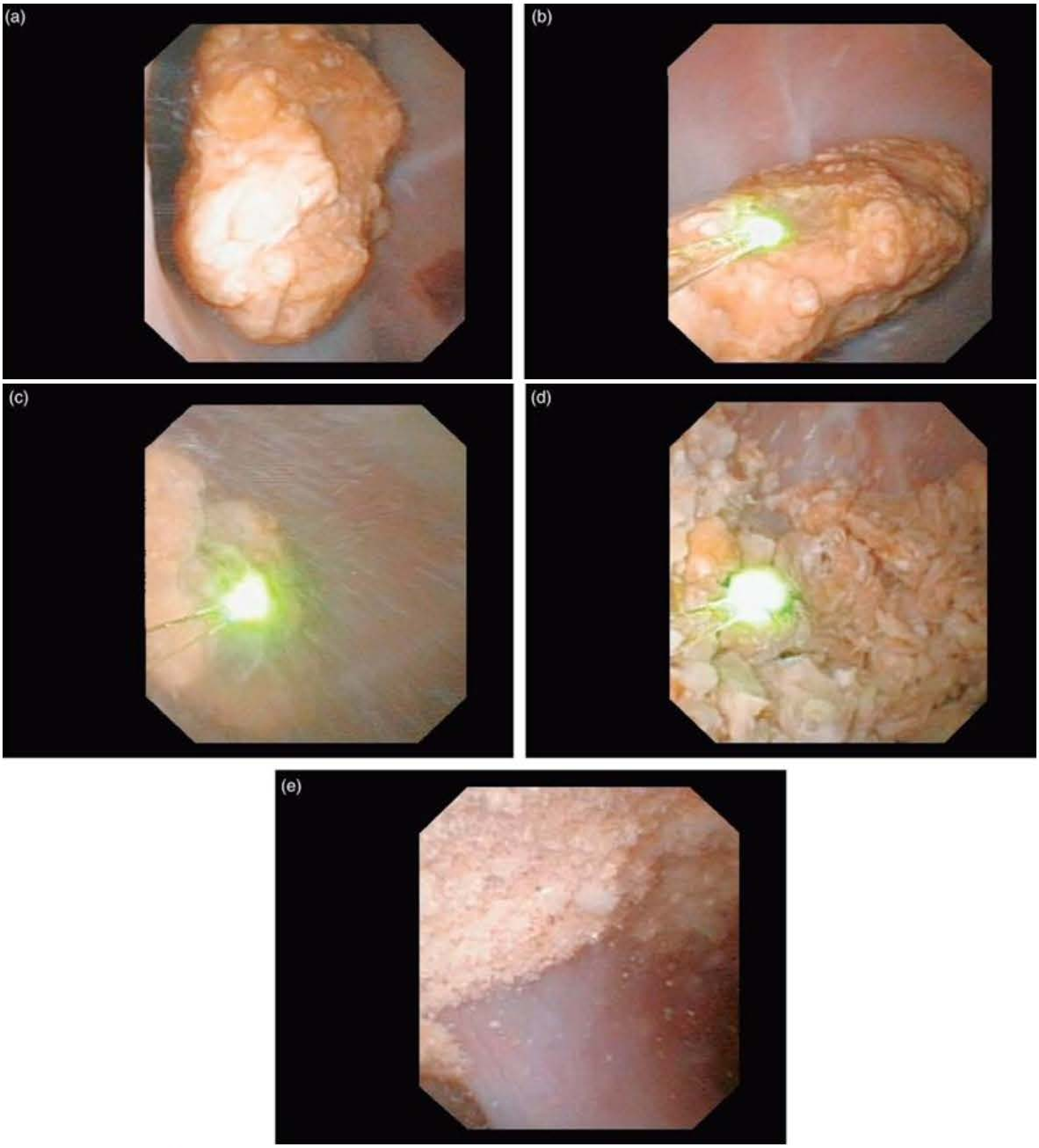


Figure 6.79 **Caliceal stone (a), fragmented by Ho:YAG laser (b–d) into sand (e).**

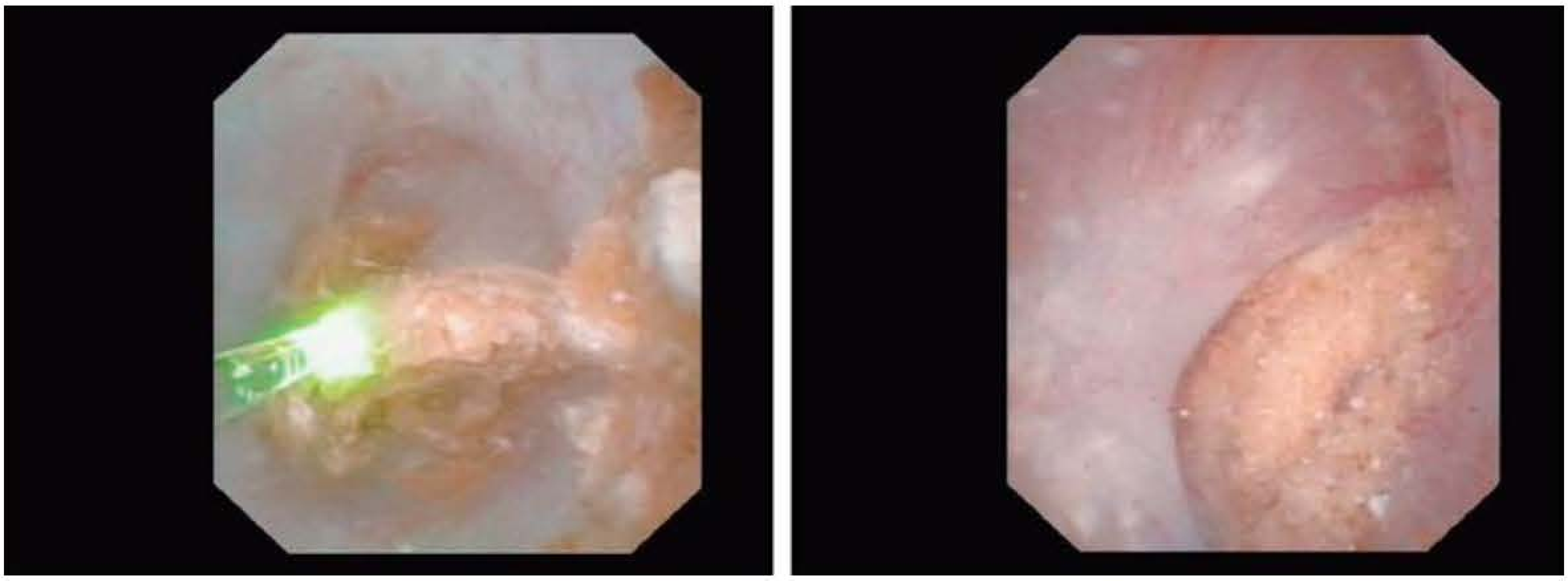
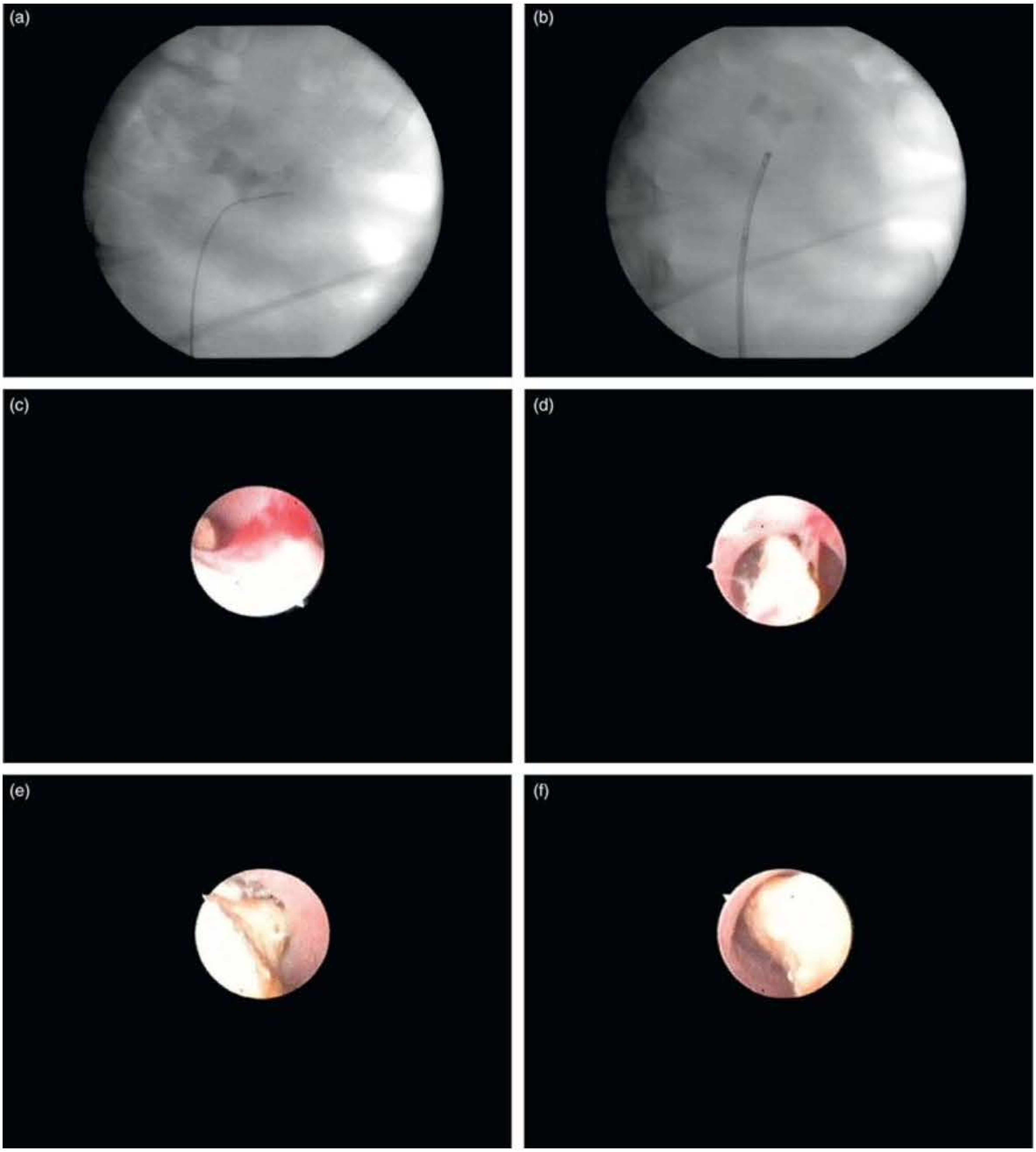


Figure 6.80 Sand resulting from Ho:YAG laser lithotripsy.

The dimensions of the stones can significantly influence the results of flexible ureteroscopy (Geavlete et al., 2007b; Mulțescu et al., 2007). Although retrograde flexible ureteroscopic approach of large pyelocaliceal calculi is possible (Figs 6.81 and 6.82), the success rate in these cases is lower.



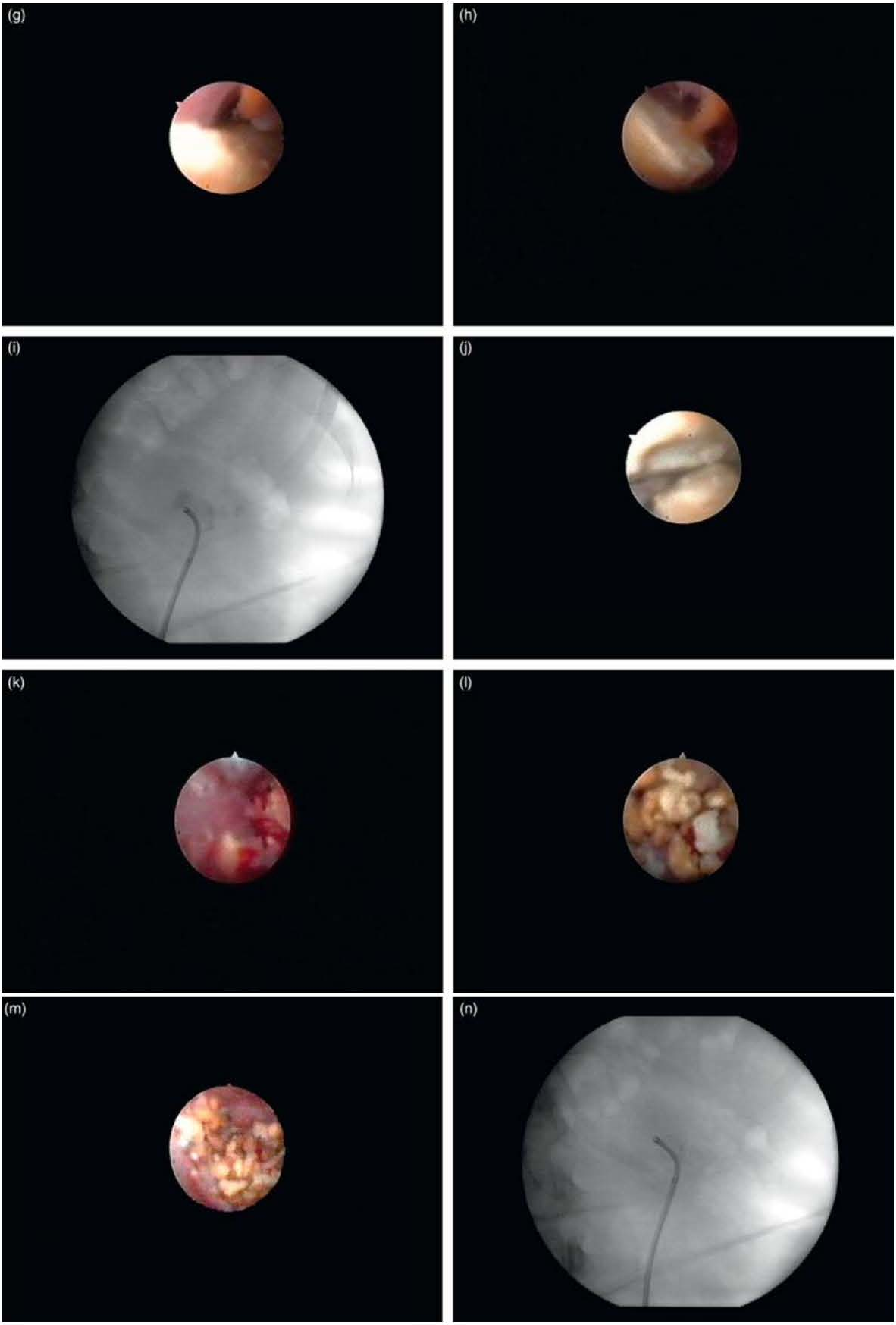


Figure 6.81 **Flexible ureteroscopic treatment of a large stone.**
Approach of the upper caliceal stone (a–f), electrohydraulic lithotripsy of the stone (g–l), very small (<2 mm) multiple lithiasic fragments after lithotripsy (m, n).

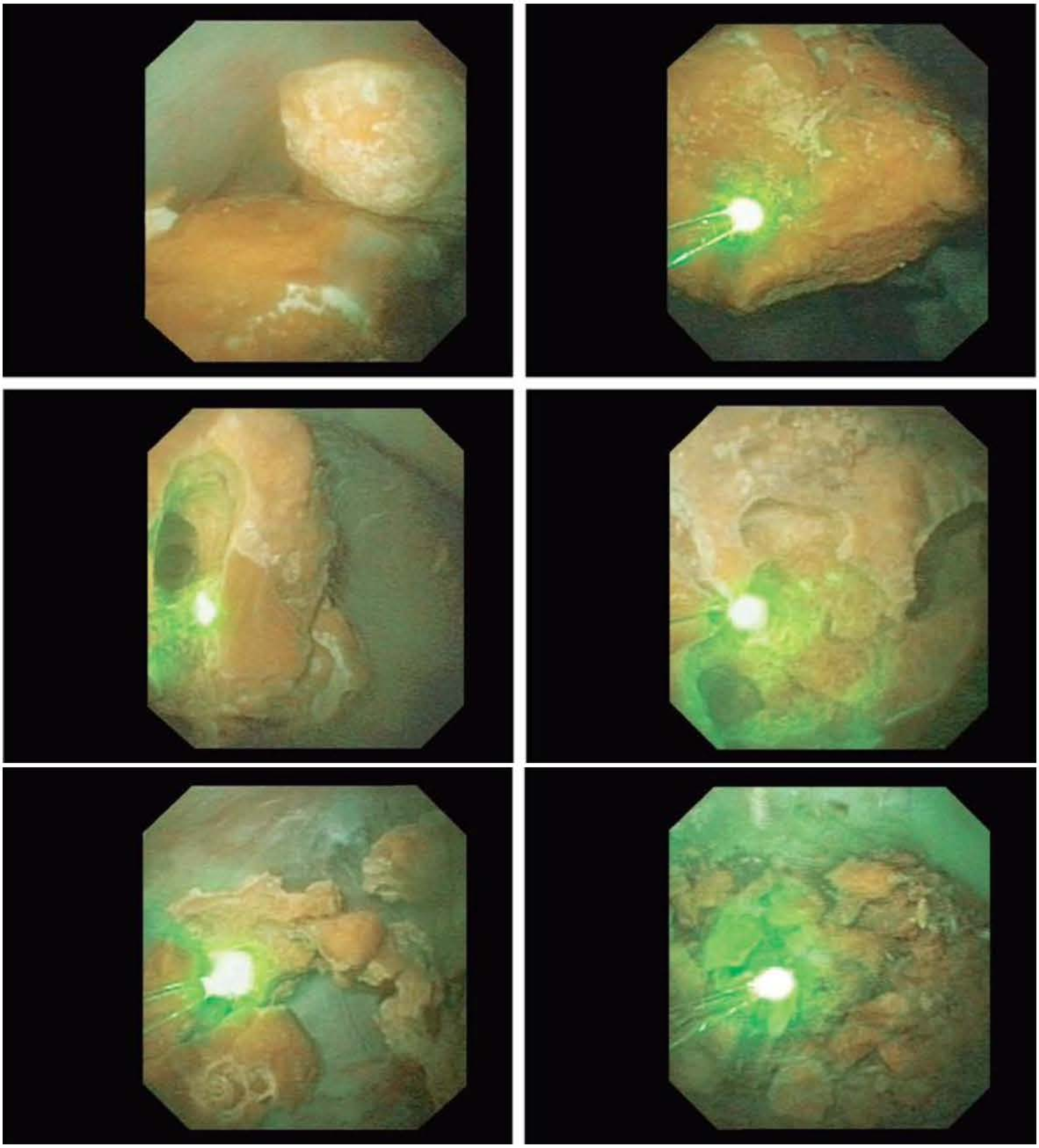


Figure 6.82 **Large multiple caliceal lithiasis for which laser lithotripsy into fragments of maximum 3 mm is performed.**

Grasso and Ficazzola report, after a single procedure, success rates (stone-free or lithotripsy into fragments smaller than 2 mm) of 94% for calculi with dimensions of up to 10 mm, 95% for those between 11 mm and 20 mm, and of only 45% for those larger than 20 mm.

For the third category, after additional flexible ureteroscopic interventions (in some cases associated with irrigation of the upper tract for 36 h in order to eliminate the small fragments), the success rate increased to 82% (Grasso and Ficazzola, 1999). Similarly, El-Anany et al. (2001) report a success rate of 77% in a group of 30 patients with lithiasis larger than 20 mm.

The influence of the stones' localization on the intervention's success rate has also been assessed (Fig. 6.83). Thus, flexible ureteroscopic approach for lower caliceal lithiasis presented a success rate ranging between 79% and 91%, in some cases requiring multiple interventions (Grasso and Ficazzola, 1999; Kourambas et al., 2000; Hollenbeck et al., 2001; Schuster et al., 2002).

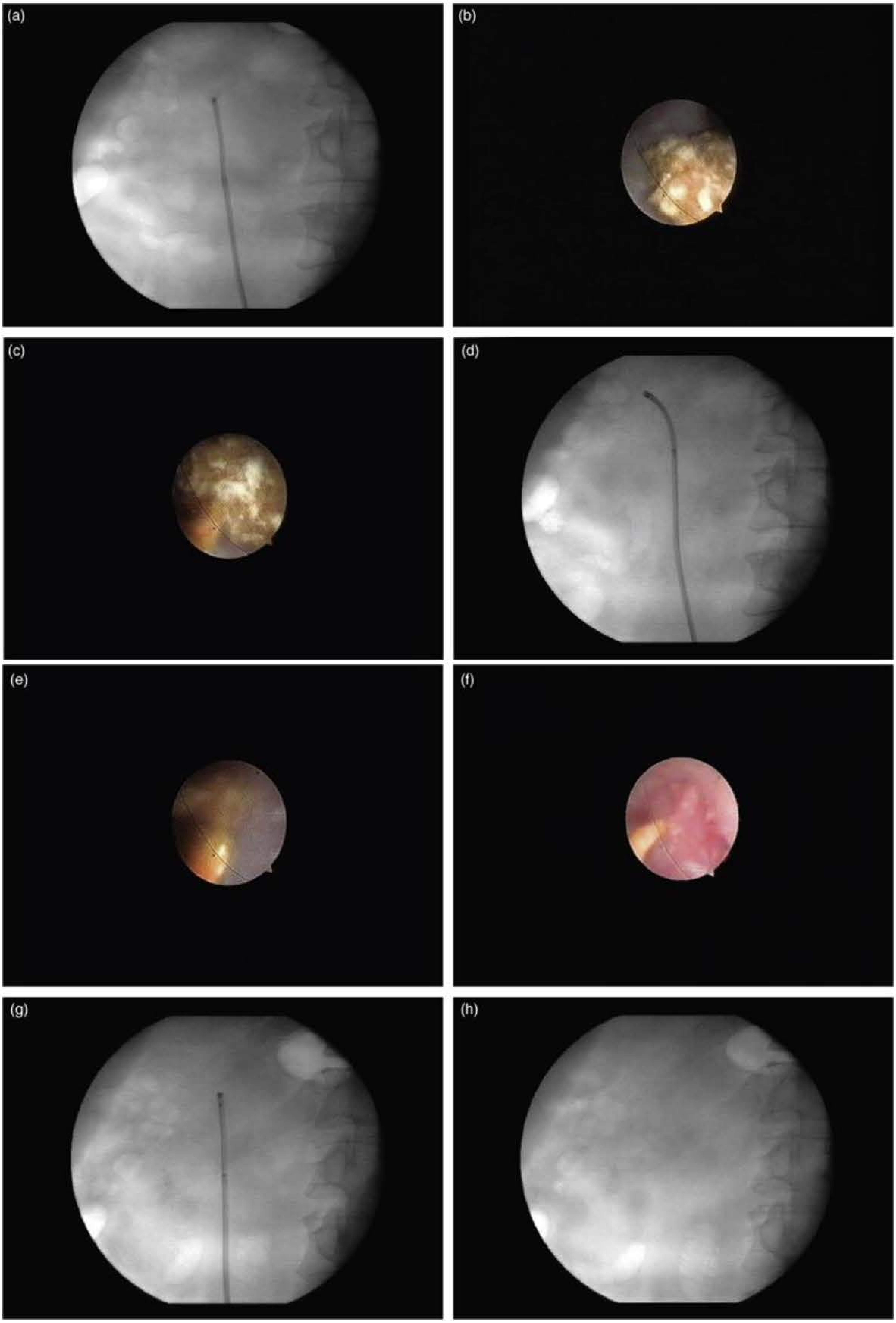


Figure 6.83 **Flexible ureteroscopic approach of an upper caliceal stone (a, b), with *in situ* electrohydraulic lithotripsy (c–f), and stone-free final fluoroscopic control (g, h).**

The use of the technique of dislocating the stone from the lower calyx and fragmenting it in more easily accessible areas of the pyelocaliceal system, such as the renal pelvis or the upper calyx, improves the method's results (Fig. 6.84).

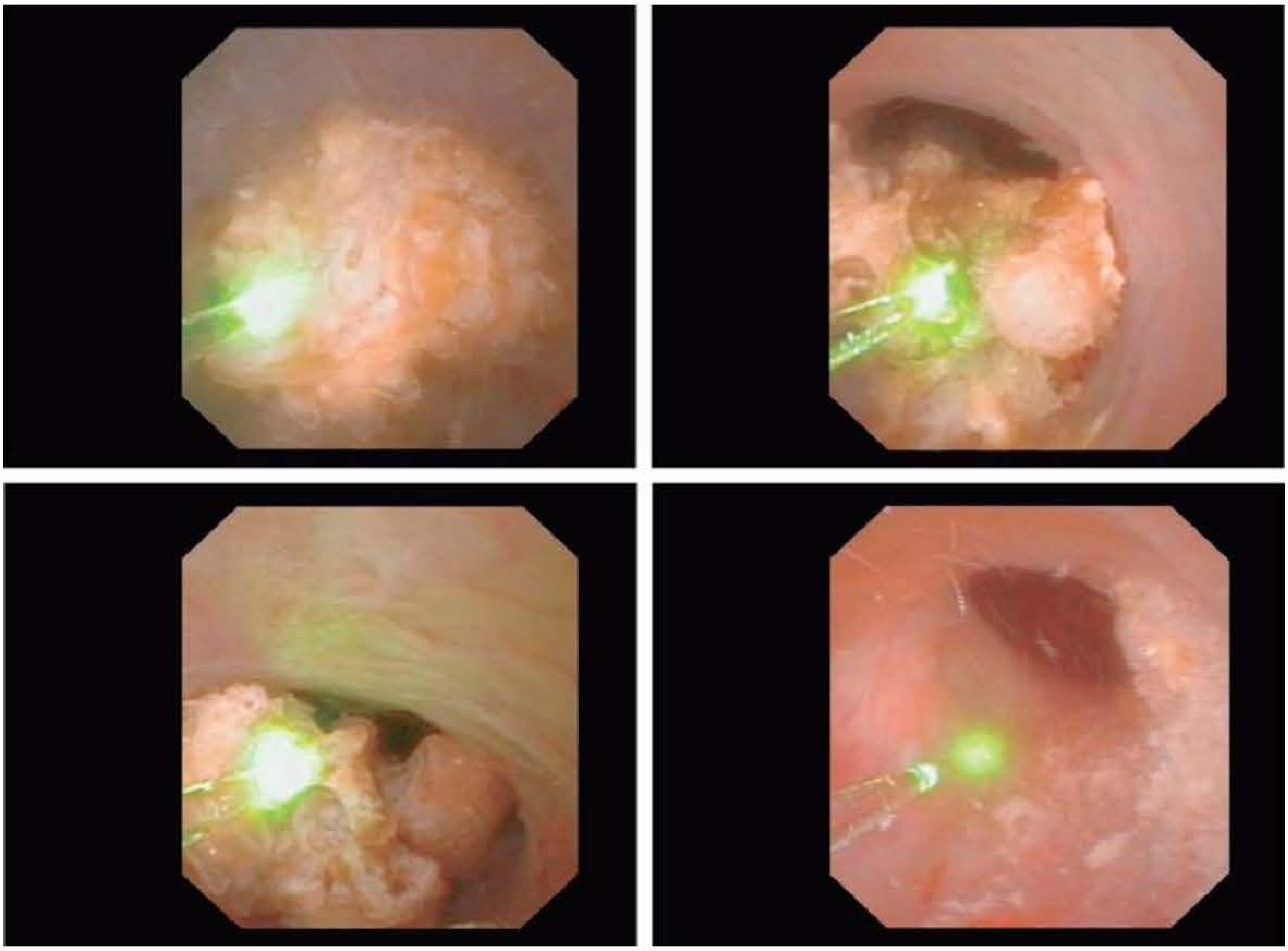


Figure 6.84 **Laser lithotripsy of a lower caliceal stone after repositioning in the upper caliceal infundibulum.**

Thus, Schuster and coworkers report, for lithiases smaller than 10 mm, success rates of 77% in patients who underwent *in situ* lithotripsy compared to 89% in those in whom the dislocation technique was applied. For calculi with dimensions between 10 mm and 20 mm, the success rates were of 29% and 100%, respectively (Schuster et al., 2002). Kourambas et al. (2000) applied this technique only in cases in which *in situ* lithotripsy was not possible, obtaining an improvement in the success rate from 83% to 90%.

Since alteration of visibility or the impossibility of accessing certain areas of the pyelocaliceal system are frequent causes for the method's failure, the mechanical properties of the flexible ureteroscopes used may have a significant impact on the method's results. The use of latest-generation models, with better maneuverability at the pyelocaliceal level and with improved optical systems, allows for treating some calculi that cannot be approached with the older ureteroscopes. Thus, Ankem and coworkers analyzed 54 consecutive flexible ureteroscopies, performed in 37 patients, the ACMI DUR-8 Elite model (with two active deflections) being used when its predecessor, the ACMI DUR-8 (with a single active deflection), proved to be inefficient. For the third-generation ureteroscope, the rate of use was 28.9% (57.1% for the lower pole), while the success rate was 69.2% (75% for the lower pole) (Ankem et al., 2004).

6.6. Incidents and complications of retrograde ureteroscopy

Although ureteroscopic approach represents a minimally invasive technique for treating upper urinary tract lithiasis, it can be encumbered by the occurrence of intra- or postoperative incidents and complications (Abdel-Razzak and Bagley, 1994; Cheung et al., 2001). Recent technical advances have led to a decrease in the rate and severity of complications (Chow et al., 2003). Thus, the introduction into clinical practice of flexible ureteroscopes has determined a significant reduction in the incidence of traumatic lesions of the ureteral wall (Francesca et al., 1995).

Although technological evolution has revolutionized the diagnostic and therapeutic approach of the upper urinary tract, iatrogenic traumas represent an important problem, with an incidence varying in different statistics between 2% and 20% (Heney et al., 1981; Blute et al., 1989; Low et al., 1993). Major complications are considered those that require surgical intervention or endanger the life of the patient, while minor complications can be resolved by nonsurgical measures.

Most complications of ureteroscopy are minor, without requiring specific measures or which can be resolved endoscopically (Geavlete et al., 1999a). The major complications of ureteroscopy, although having a reduced incidence, can be severe, determining significant sequelae.

Although a system for formally classifying the lesions secondary to ureteroscopy has not been established, most authors have defined them according to the moment of occurrence and severity. Although most complications occur intraoperatively, their sequelae may appear in the immediate or late postoperative period.

Other complications initially occur in the postoperative period, without being determined by intraoperative incidents or complications.

6.6.1. Intraoperative Incidents

6.6.1.1. Difficulties of Ureteroscopic Access

Despite the advances in the design of ureteroscopes, which have improved access to the upper urinary tract, this can be encumbered by difficulties in approaching the ureteral orifice, negotiating the intramural ureter and progression of the ureteroscope. The favoring causes are represented by the patient's anatomic modifications, the narrowing of the ureteral lumen through stenosis or extrinsic compression, obstruction secondary to edema or impacted calculi, ureteral lesions, or instrument failure (Flam et al., 1988). Schuster et al. (2001), in a group of 322 patients, observed an incidence of 1.6% incidents related to the ureteral access.

The impossibility of passing the ureteral orifice with the guidewire may be due to the presence of a large prostatic median lobe, cystocele, ureterocel, edema, or a stenosis at this level.

One of the following solutions can be chosen to surpass this impediment: voiding the urinary bladder, using a flexible cystoscope to facilitate placing the guidewire in patients with a bulky prostatic median lobe, using hydrophilic guidewires, or placing the guidewire under ureteroscopic control. Very rarely (patients with neoplasic obstruction, large calculi impacted in the intramural ureter, or after iatrogenic lesions appearing after ureteroscopy or endoscopic resection), failure of the other methods may require placing the guidewire in an antegrade manner.

Another incident is represented by the impossibility of surpassing the lithiasic obstacle with the guidewire. In this situation, a ureteral catheter can be ascended up to 1–1.5 cm from the stone. Through this catheter, under fluoroscopic control, a hydrophilic guidewire is inserted making the impacted stone easier to surpass. Subsequently, the catheter is ascended above the obstacle, and the hydrophilic guidewire is replaced by a normal guidewire. If the obstacle still cannot be surpassed in this way, the ureteroscope can be ascended up to the level of the stone, advancing the guidewire under direct visual control. In case of failure, percutaneous puncture of the pyelocaliceal system is recommended, placing the guidewire in an antegrade manner under fluoroscopic control, up to the urinary bladder. The next alternative is to place the guidewire under antegrade ureteroscopic control. If the lithiasic obstacle cannot be surpassed with the guidewire either in a retrograde or in an antegrade manner, it is recommended that a percutaneous nephrostomy be performed and the retrograde maneuvers be resumed after 2 weeks.

The difficulties in the ureteroscopic approach of the ureteral orifice may occur either as a result of the fact that it was not dilated, or because of an insufficient dilation. The use of balloon catheters (Fig. 6.85) has determined a reduction in the frequency of these incidents, allowing for an easier and quicker access to the ureter, which represents an essential aspect when repeated passages of the ureteroscope are necessary (Chow et al., 2003).

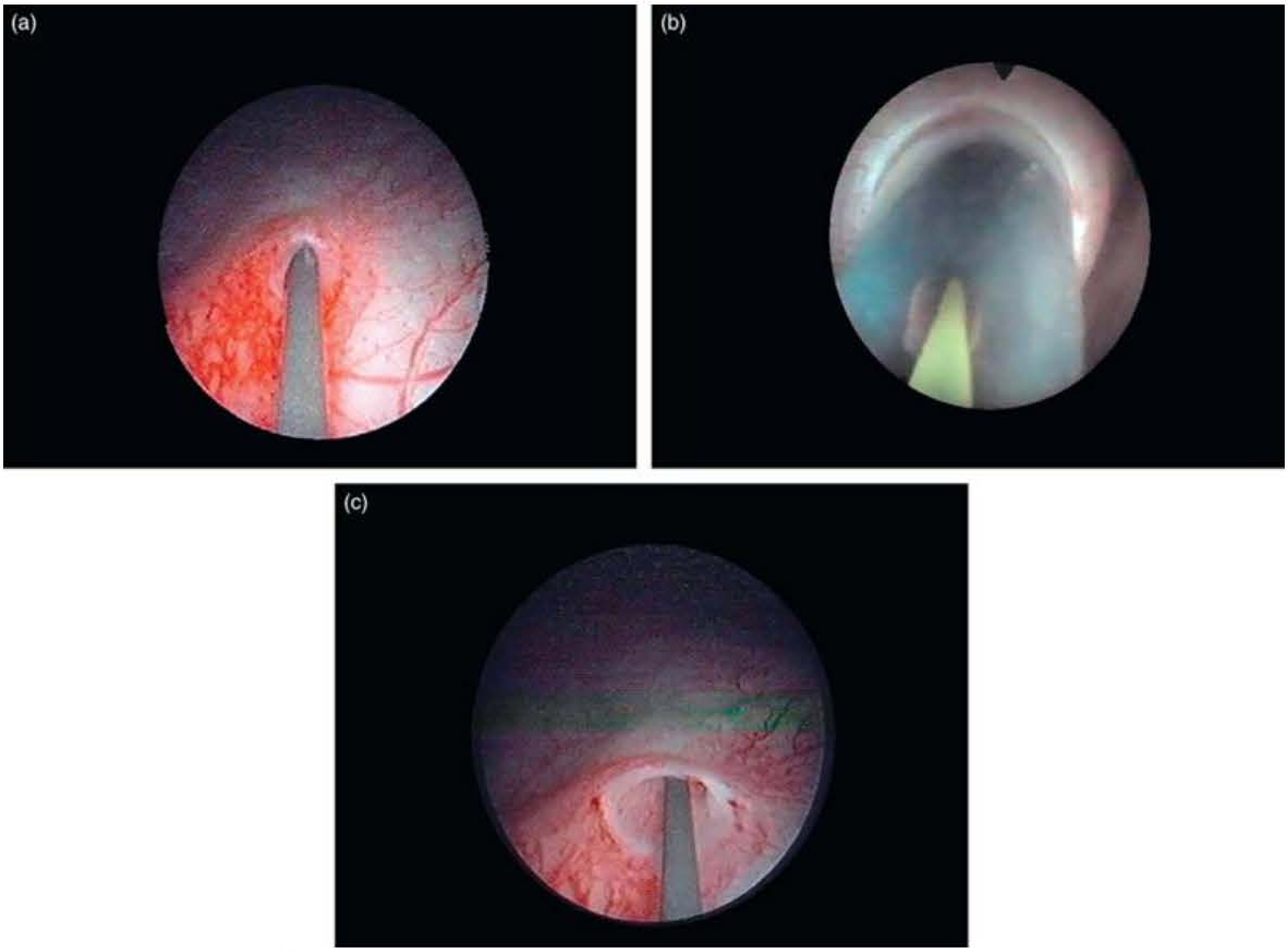


Figure 6.85 **Dilation of the ureteral orifice with a balloon catheter.**
Hydrophilic guidewire (Terumo) inserted into the ureter (a), inflation of the balloon (b), aspect of the ureteral orifice after dilation (c).

The impossibility of ascending the ureteroscope may be determined by the edema subjacent to the stone (especially in the case of impacted calculi) (Fig. 6.86), important sinuosities (Fig. 6.87), as well as the existence of rigid, stenosed areas of the ureteral lumen. The latter appear, most frequently, as a result of surgical interventions or at the level of the areas of physiological narrowing of the lumen.

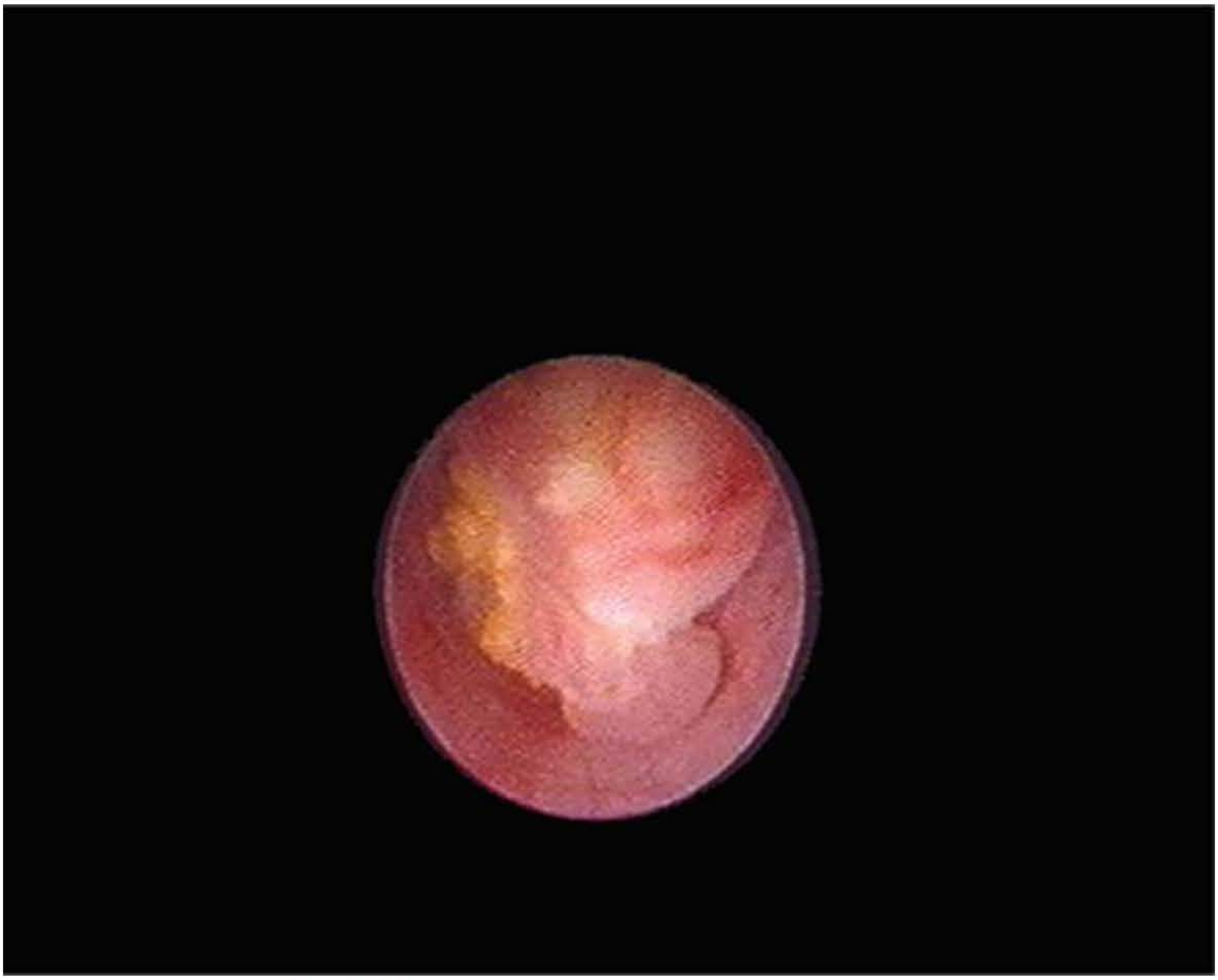


Figure 6.86 Important ureteral edema subjacent to the stone.

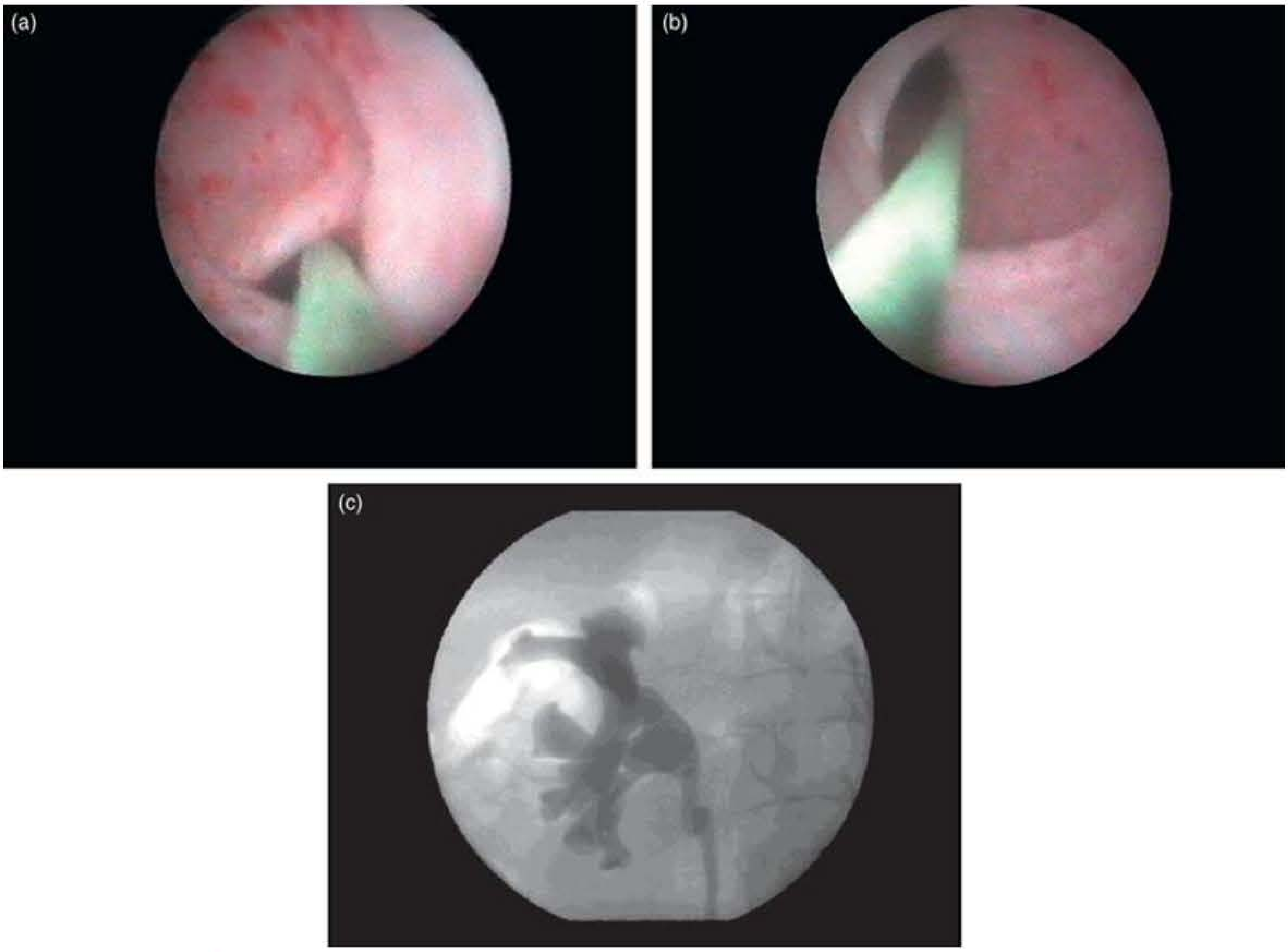


Figure 6.87 **Endoscopic (a, b) and radiological (c) aspects of ureteral sinuosities.**

A correct selection of patients and the use of adequate technique and instruments may reduce this incident. The use of ureteroscopes with a small caliber facilitates access to the upper urinary tract. If the ureteroscope cannot be ascended safely into the tortuous or stenosed segments of the ureter, it is recommended that a JJ stent be placed for realignment and passive dilation. This usually allows for successfully resuming the procedure after 7–10 days.

6.6.1.2. Equipment or Instrument Failure

Although the introduction of small-caliber ureteroscopes and of miniaturized accessory instruments has increased the maneuverability and applicability of ureteroscopy, they have an increased fragility, causing an increased incidence of failure (Afane et al., 2000; Fig. 6.88).

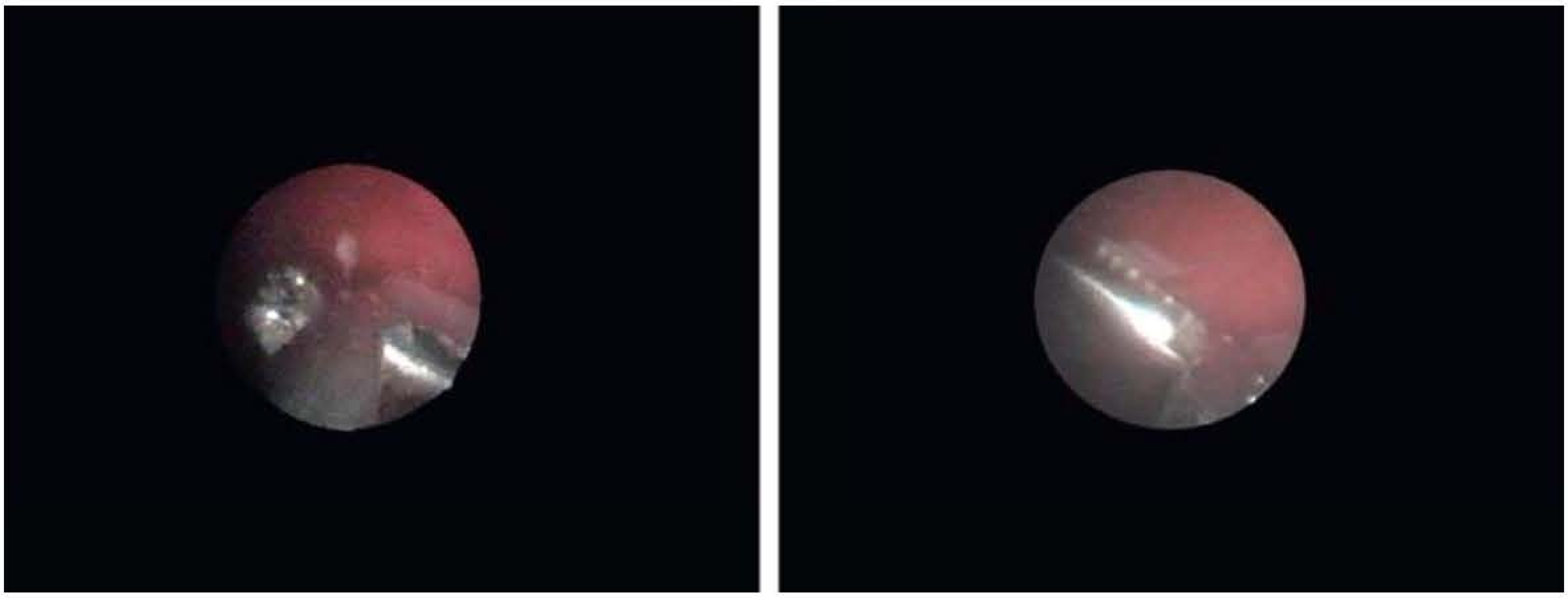


Figure 6.88 **Extracting clamp deteriorated during ureteroscopy.**

Abdel-Razzak and Bagley (1992) reported two cases in which the procedure was interrupted due to equipment failure, requiring its subsequent repeat. In one case, a failure of the laser generator occurred, while in the other case, the optical fibers of the ureteroscope broke, preventing its use. Schuster et al. (2001), in a series of 322 patients, reported six cases with incidents determined by equipment failure.

Fracture of the ureteroscope during the endoscopic maneuvers (Fig. 6.89) has been reported with an extremely low incidence (Flam et al., 1988). It can be prevented by a gentle manipulation of rigid and semirigid ureteroscopes, during which the visual field must remain perfectly round. When the field becomes elliptical, the tear of the instrument is imminent.

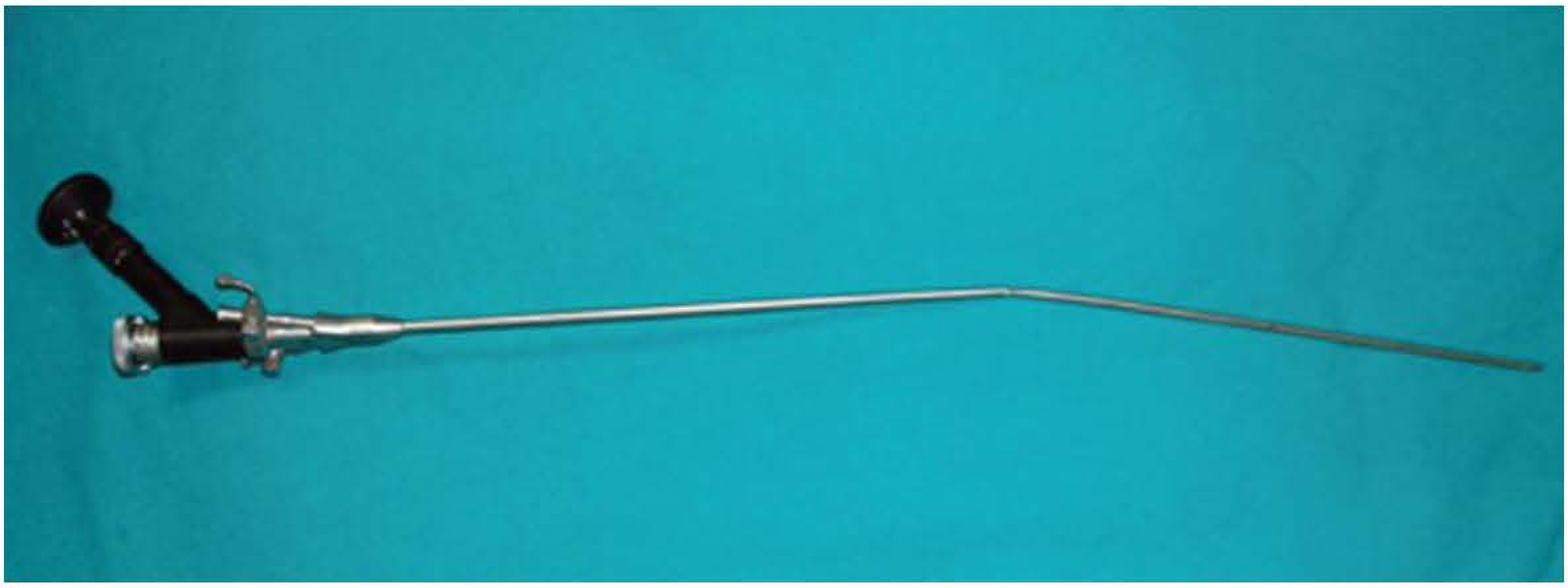


Figure 6.89 **Semirigid ureteroscope fractured intraoperatively.**

Sectioning of the guidewires can occur as a result of the deteriorations produced by the contact lithotripters. The Ho:YAG laser may determine fracture of the guidewire that is placed in direct contact with it. The guidewire fragments can be extracted endoscopically.

Iatrogenic lesions of the ureteral wall can also be produced by the tear of the balloon dilator. This can occur as a result of the rapid inflation of the balloon or of exceeding the recommended pressure. The lesions include tear of the intramural ureter, urine leakage, or bleeding. In order to prevent this incident, a gradual, monitored increase of the pressure is recommended, using a LeVeen-type syringe. Huffman and Bagley (1988) observed that a pressure of 8 atm is sufficient to achieve dilation in 78% of cases.

The true incidence of the problems related to equipment failure is underestimated. The rate of incidents determined by equipment and instrument failure can be reduced by proper maintenance during sterilization, depositing, and use. During flexible ureteroscopy, the accessory instruments must be inserted without the deflection of the proximal end in order to avoid injuring the working channel. The operator must be familiar with the equipment and the instruments, with their working mechanisms, as well as with the working settings of the lithotripsy devices. Failed equipment must be replaced, and if this is not possible, it may require stopping the procedure in order to avoid the occurrence of major complications.

6.6.1.3. Fixation of the Dormia Catheter

Fixation of the Dormia catheter has an incidence of approximately 0.5%. Its forced extraction may lead to very severe complications determined by the tear of the ureter in the area of the stone's fixation and ureteral stripping. In most cases, fixation of the catheter can be solved endoscopically (Geavlete et al., 2000d) by extracting its external sheath and withdrawing the ureteroscope. Subsequently, the ureteroscope is advanced alongside the catheter and lithotripsy of the stone between the spirals is performed, until the extracting instrument is released (Fig. 6.90).

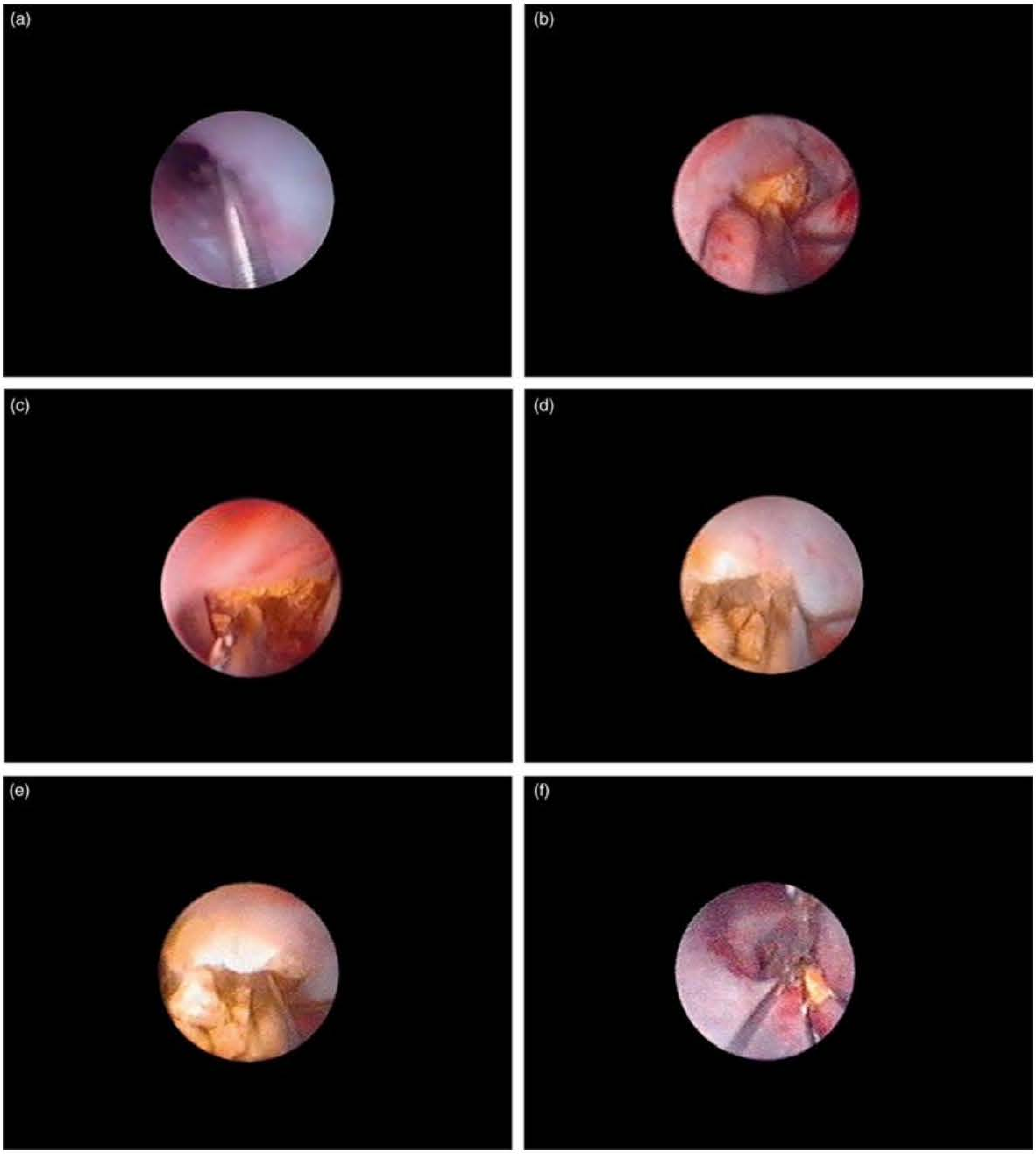


Figure 6.90 **Ureteroscopic management of a fixed basket catheter.**
Ascending the ureteroscope alongside the disassembled catheter (a), ballistic lithotripsy of the stone between the catheter's spirals (b–e), extraction of the released basket catheter (f).

6.6.1.4. Proximal Migration of the Stone

The proximal ascent of the stone represents a frequent incident, especially in the case of proximal ureteral stones. The risk of ascending migration depends on the initial localization of the stone and the degree of suprajacent urinary tract dilation, with a rate ranging from 5% to 10%. Before the introduction of flexible ureteroscopes, this incident required subsequent treatment by SWL or PNL, with or without placing a ureteral stent (Fig. 6.91).

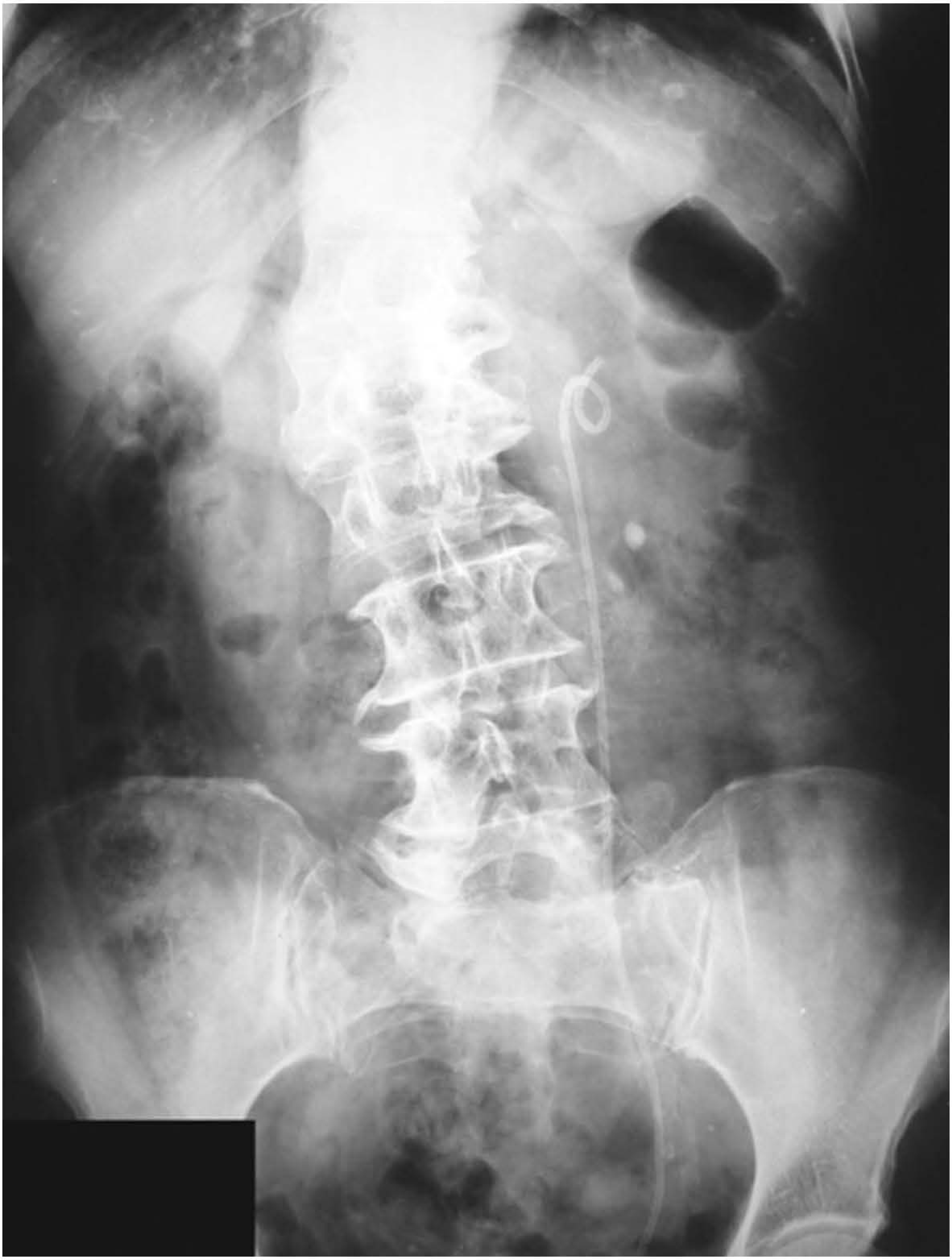


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Figure 6.91 **JJ stent placed after the ascending migration of the ureteral stone.**

Presently, migrated calculi can be treated during the same intervention by semirigid retrograde approach (if the new position of the stone allows) (Fig. 6.92) or flexible retrograde approach (Fig. 6.93).

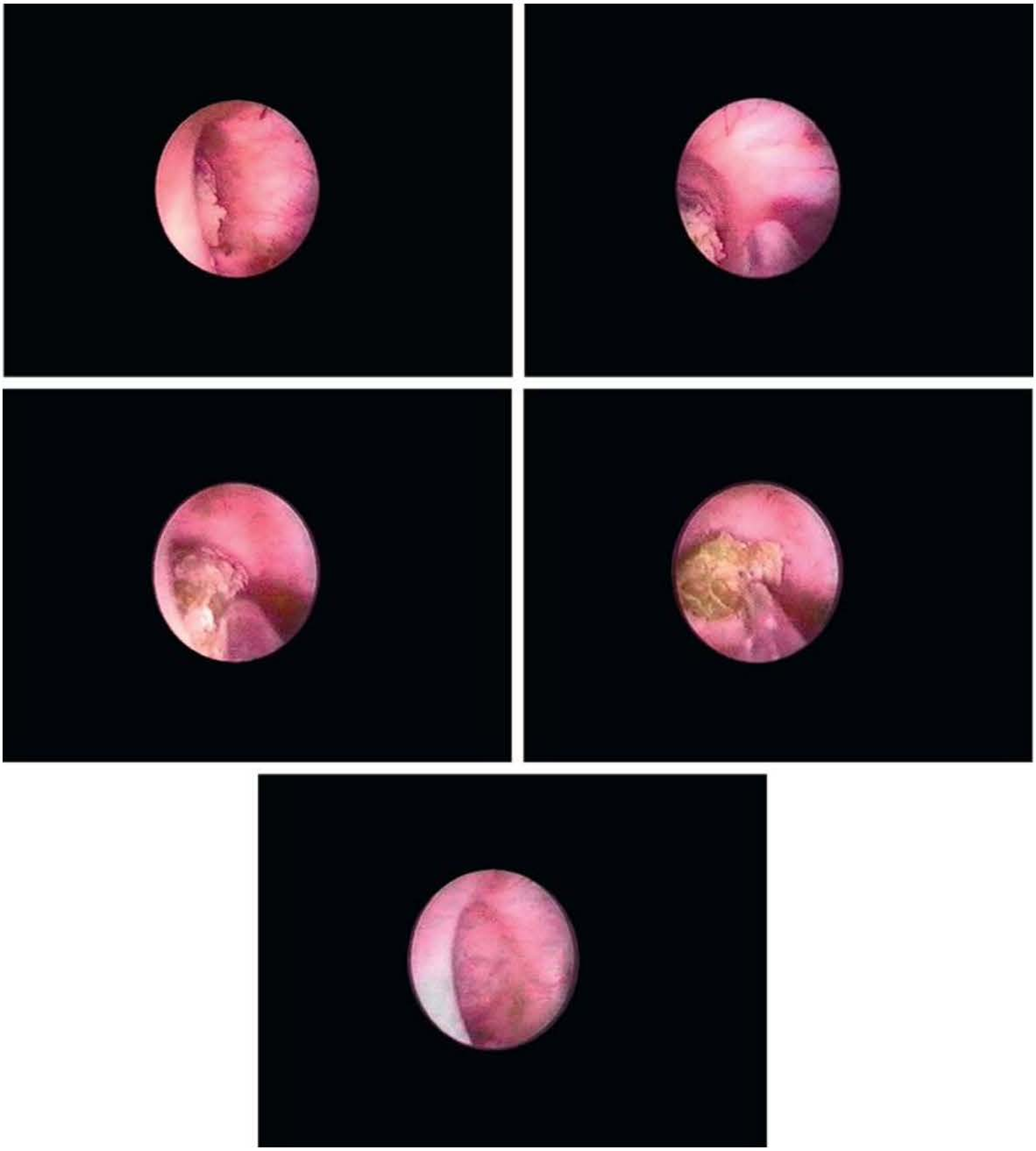

Figure 6.92 **Semirigid ureteroscopic approach of a stone migrated into the upper calyx, with ballistic lithotripsy at this level.**

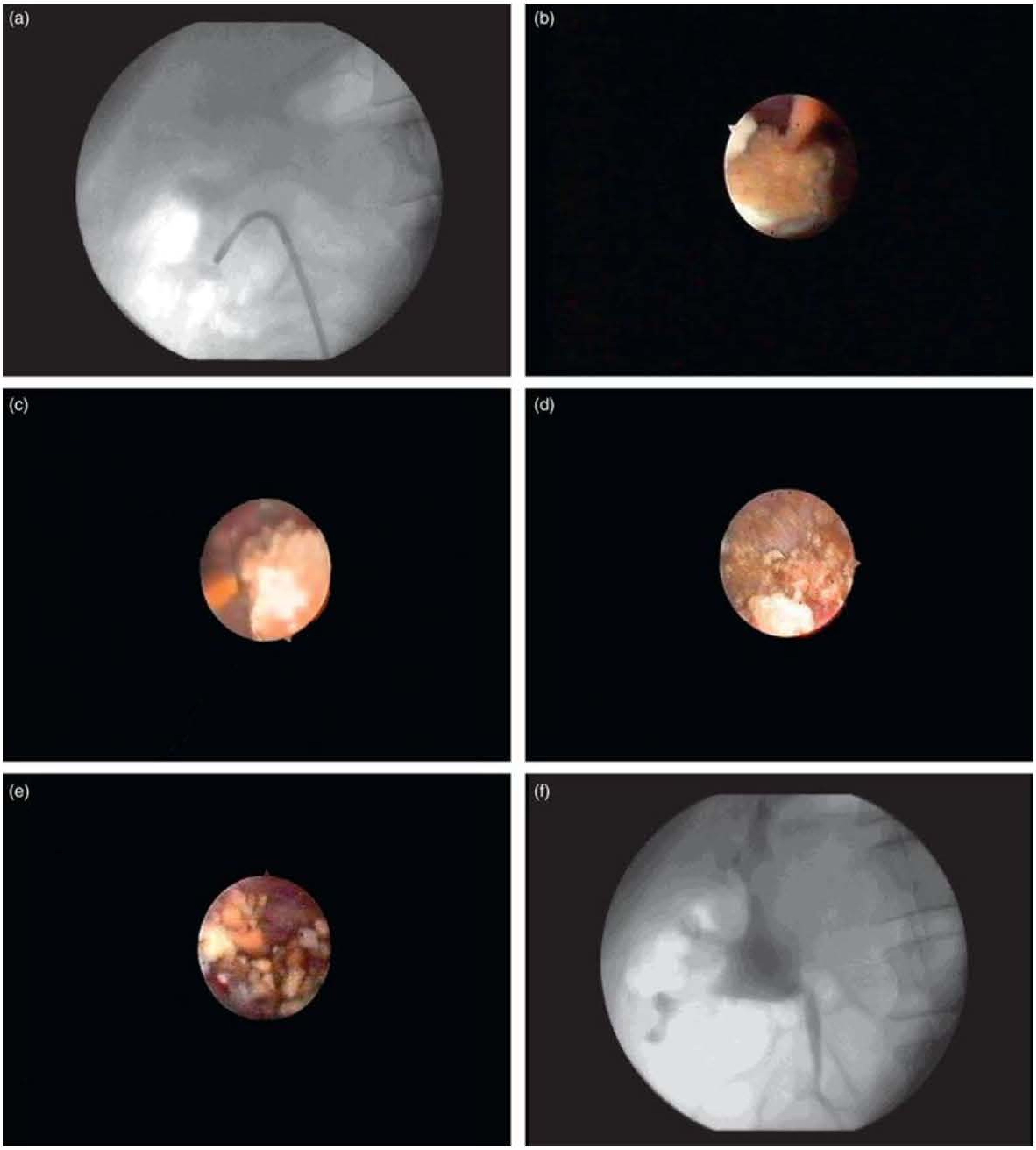

Figure 6.93 **Flexible ureteroscopic approach of a ureteral stone migrated into the lower calyx (a), with *in situ* electrohydraulic lithotripsy into lithiasic fragments smaller than 2 mm (b–f).**

Due to the multiple alternatives for solving this issue, many authors no longer consider the upward migration as an operative incident.

Ascent can be prevented by using balloon catheters or special catheters (Fig. 6.94) that obstruct the ureteral lumen above the stone.

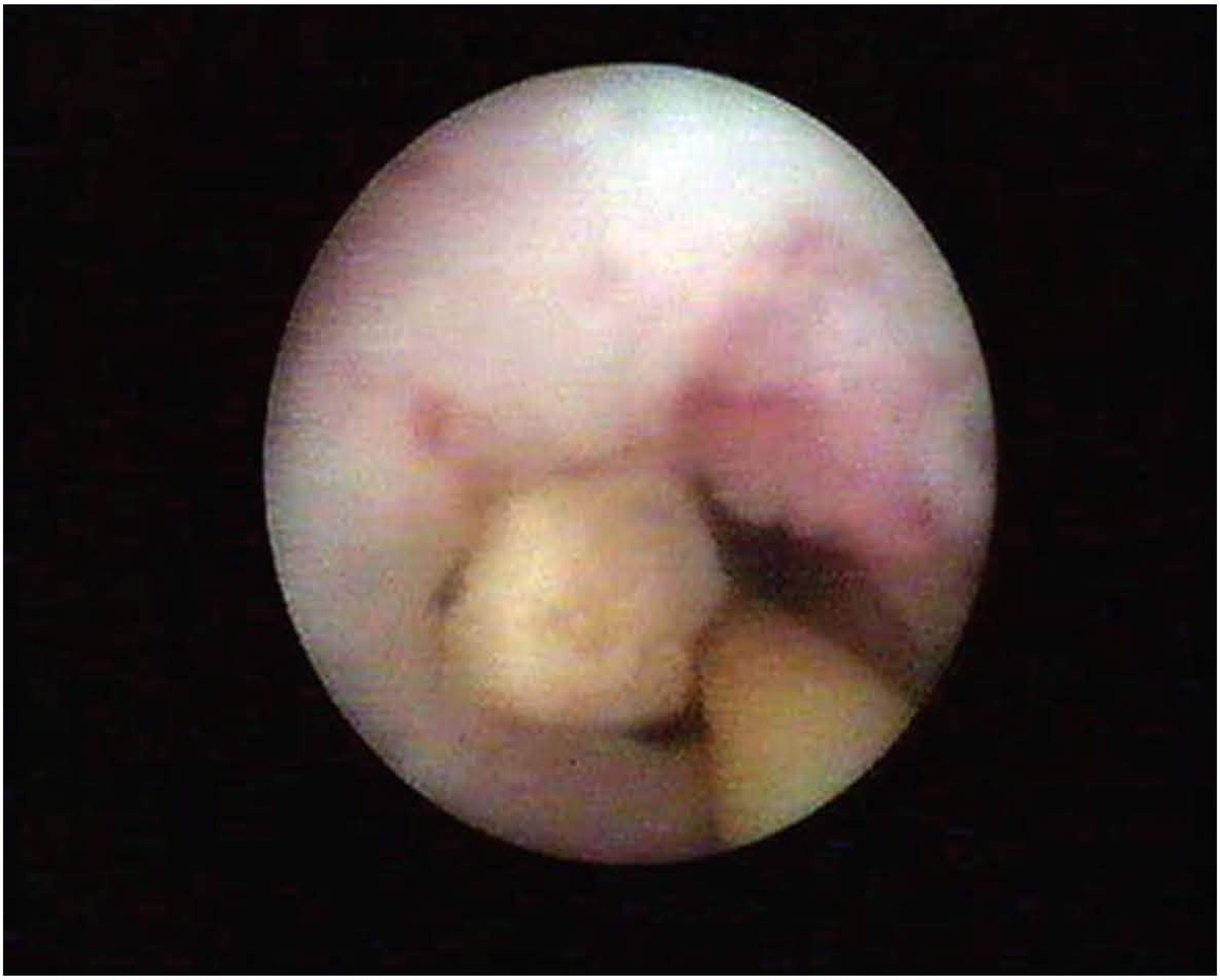

Figure 6.94 Ureteral stone fixed to a catheter inserted lateral to it.

6.6.1.5. Malposition of the Ureteral Stent

Malpositioning of the ureteral stent (Fig. 6.95) has a low incidence, being more frequent if the intervention is not performed under fluoroscopic control.

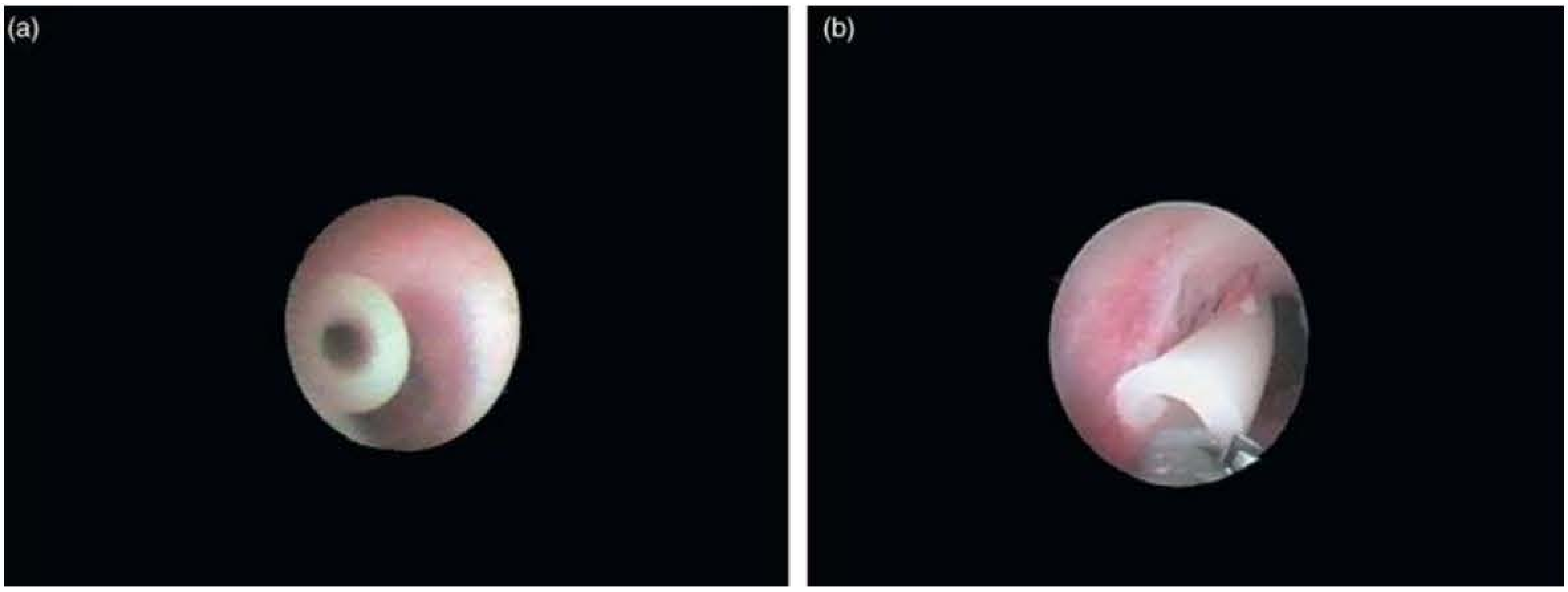

Figure 6.95 JJ stent ascended through the ureter (a), extracted with a clamp under ureteroscopic control (b).

6.6.2. Intraoperative Complications

The intraoperative complications of ureteroscopy have an incidence ranging between 0.5% and 20%, according to the published data (Biester and Gillenwater, 1986; Shultz et al., 1987; Lytton et al., 1987; Blute et al., 1988; Daniels et al., 1988; Harmon et al., 1997; Shokeir, 1997).

The minor complications are the most frequent and, in most cases, can be treated in a conservative manner by ureteral stenting, without subsequent secondary consequences. They include false submucous trajectory, minimal lesions of the ureteral mucosa, extraureteral migration of the stone, and perforation of the ureteral wall.

Severe ureteral lesions are rare, with an incidence of 1.5–5%. They are accompanied by significant bleeding and urine leakage.

When retrograde ureteroscopic approach was first introduced in the treatment of ureteral lithiasis, most traumatic complications occurred during the maneuvering of large lumbar calculi, in the conditions of limited fragmentation possibilities. Due to its anatomic conformation, which makes the progression of the ureteroscope difficult, the lumbar ureteral approach is predisposed to complications. Other factors contributing to complications are fibrosis secondary to previous interventions, and the dimensions, duration, and degree of stone impaction.

6.6.2.1. Minimal Lesions of the Ureteral Mucosa

The ureteroscopic approach determines the exposure of the transitional epithelium to mechanical forces that do not physiologically appear in the urinary tract. Thus, different degrees of ureteral mucosa abrasion occur (Fig. 6.96) during all ureteroscopic procedures.

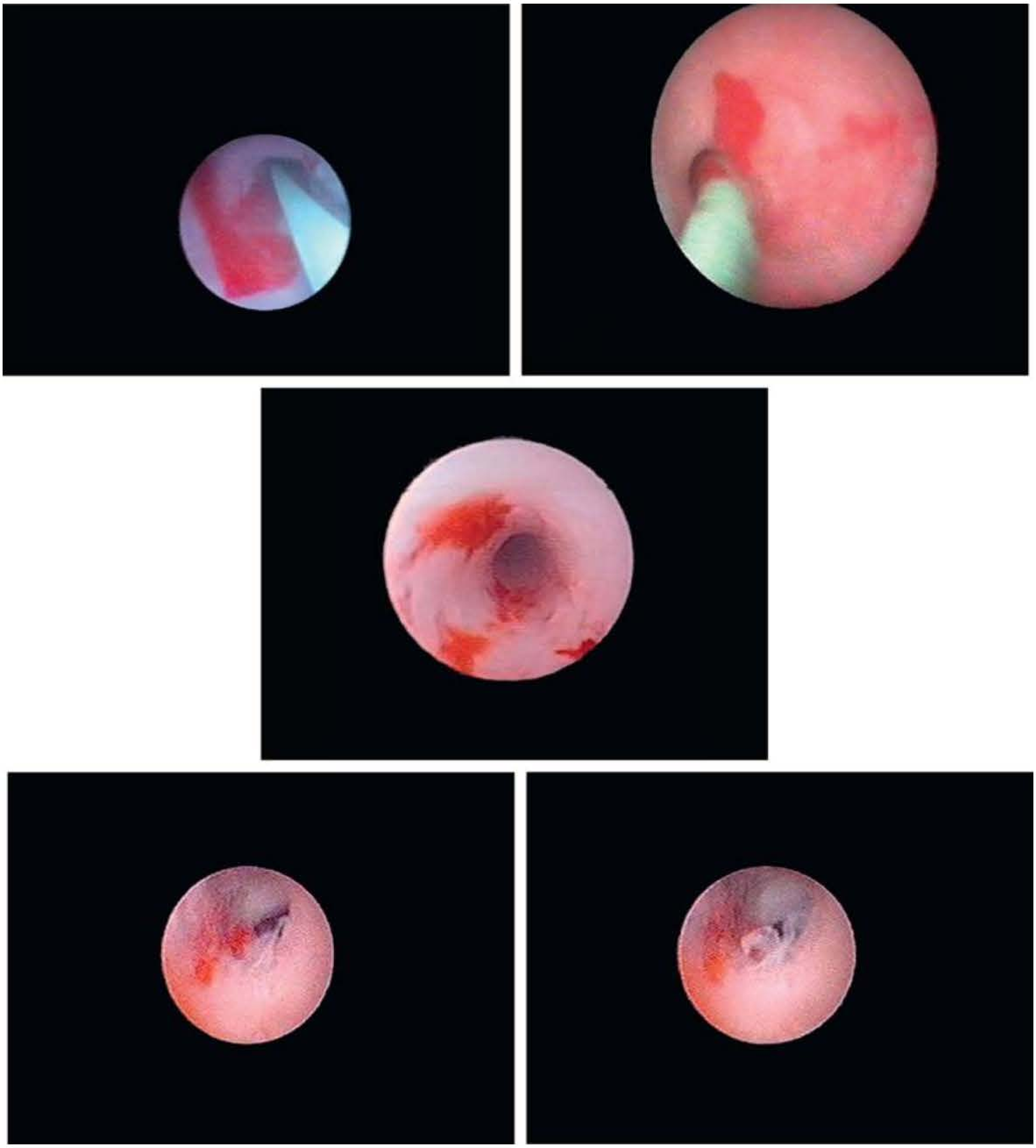

Figure 6.96 **Different aspects of minimal lesions of the ureteral mucosa occurring during ureteroscopy.**

Bleeding and edema that occur at the level of the damaged mucosa can determine a consecutive reduction in the visibility and maneuverability of the ureteroscope (Figs 6.97 and 6.98).

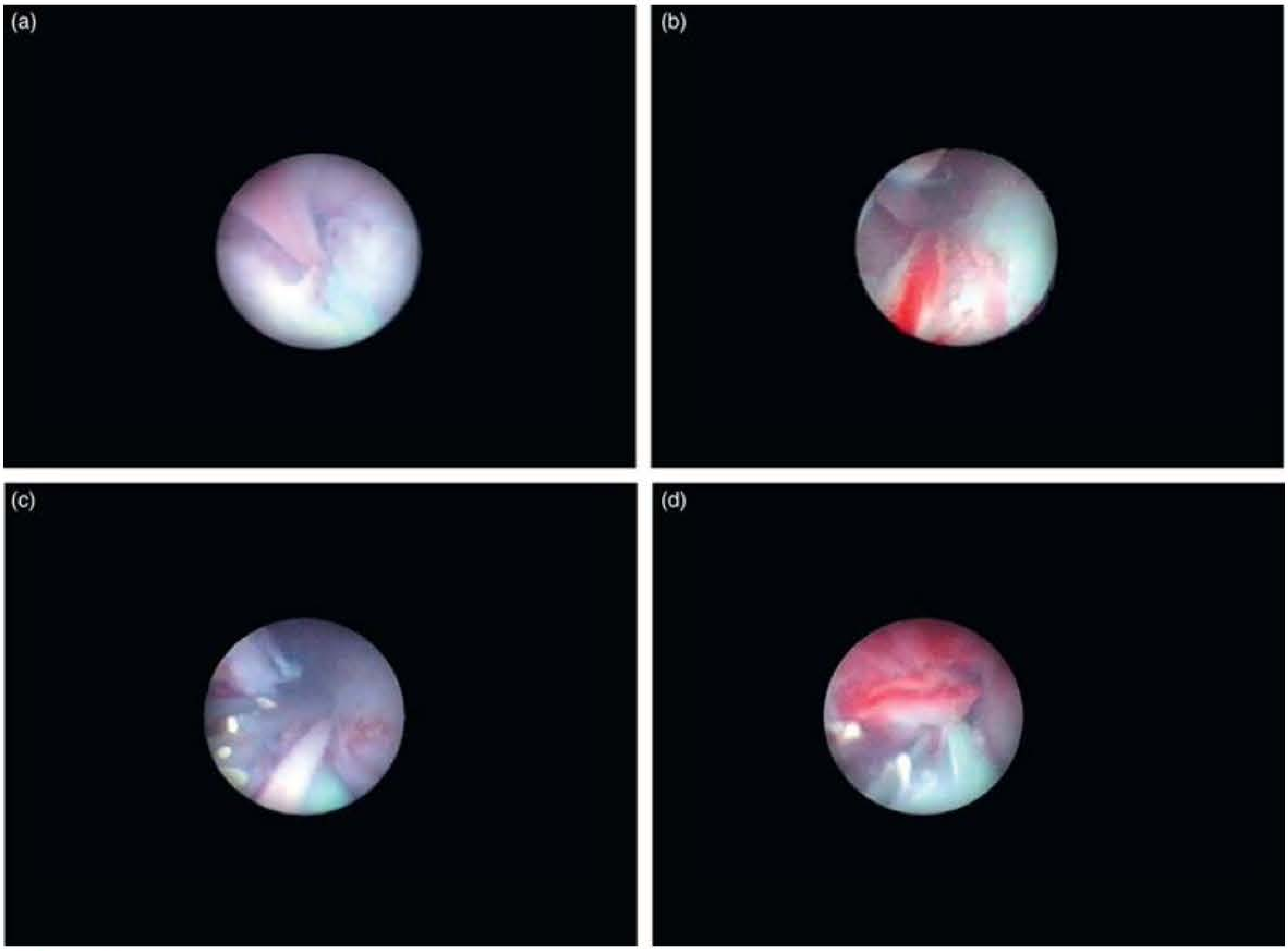

Figure 6.97 Alteration of visibility secondary to mucosal lesions (a, b), endoscopically solved by removal with a clamp (c, d).

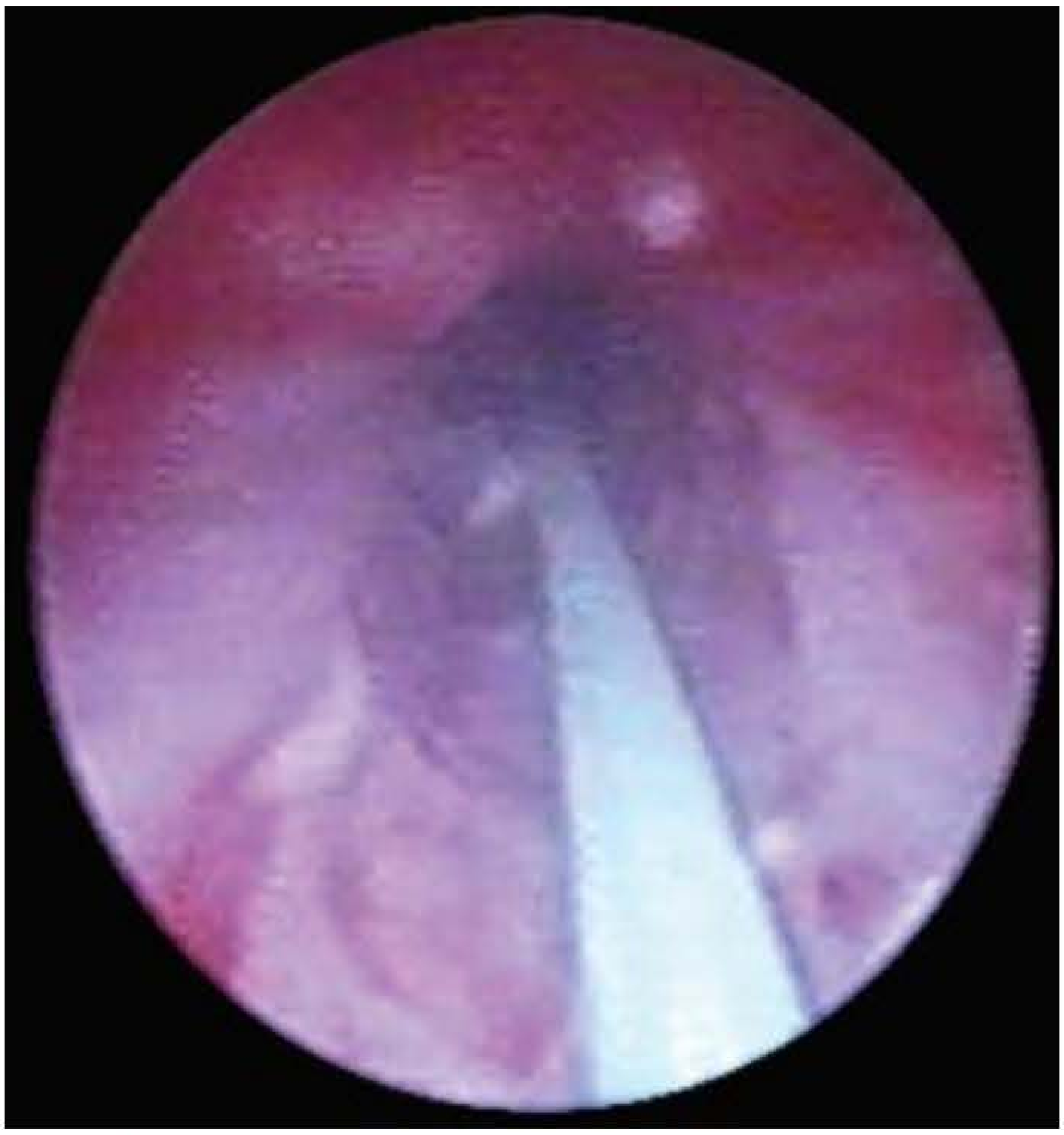

Figure 6.98 Iatrogenic lesions of the ureteral mucosa.

Francesca et al. (1995) reported an incidence of 24% of ureteral mucosa lesions after 248 ureteroscopic procedures using large-caliber instruments (9.5 or 11.5 F), compared to 6% after 49 ureteroscopies performed with low-caliber instruments (6–7.5 F). Postoperatively, the minimal lesions of the ureteral mucosa can determine ureteral obstruction secondary to edema or clots. However, using an adequate technique, the incidence of ureteral abrasion and its consequences can be reduced. If multiple passages of the ureteroscope are necessary, use of the ureteral access sheath can ensure prevention of traumatic lesions of the ureteral mucosa.

6.6.2.2. False Ureteral Passages

False passages (Fig. 6.99) can occur during the insertion of the safety guidewire (Fig. 6.100), the ureteroscope, or the different working instruments. These consist of mucosal perforation without completely crossing the ureteral wall. False passages can frequently occur as a result of the attempt to surpass an impacted ureteral stone with the guidewire.

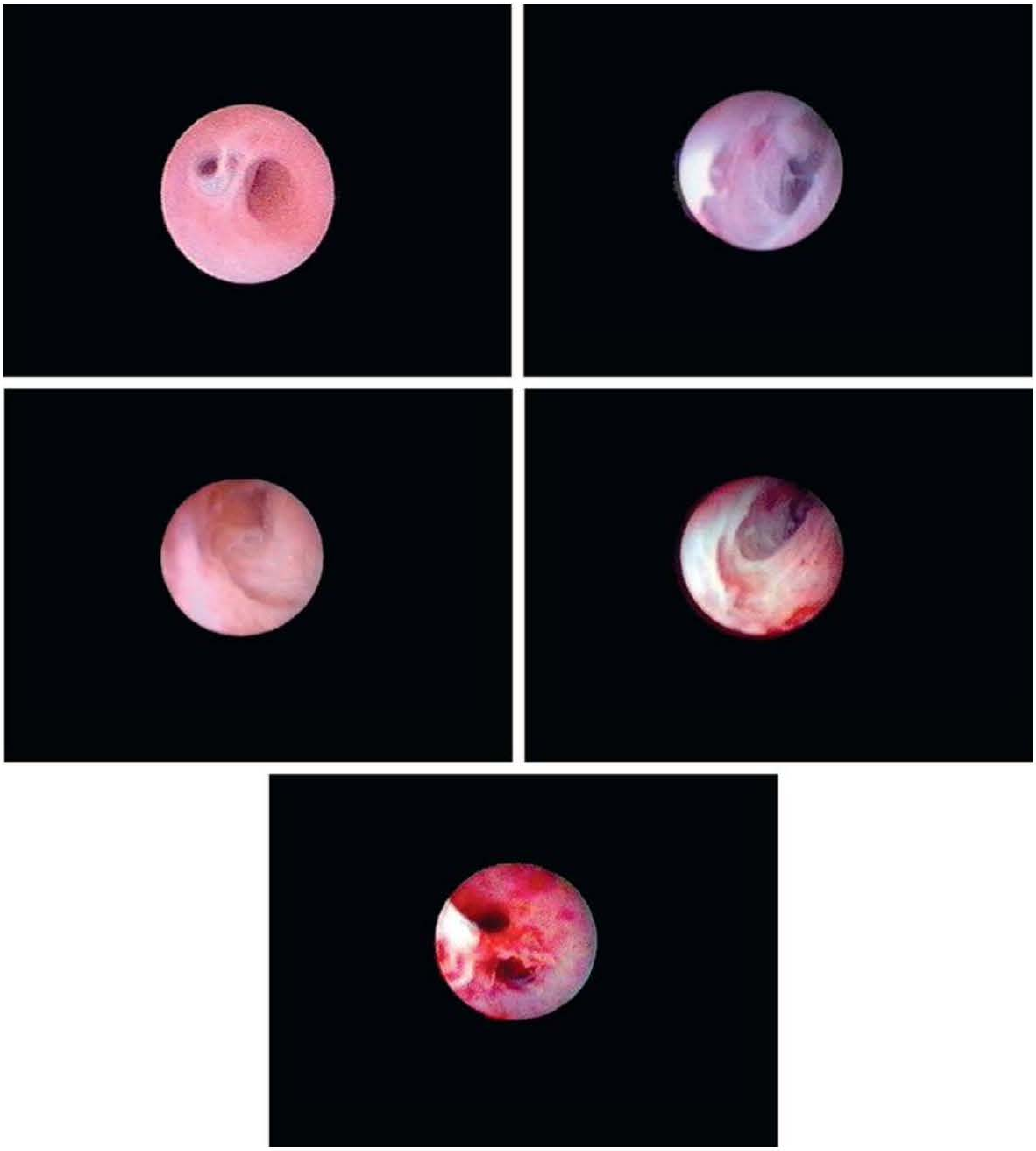

Figure 6.99 **Ureteroscopic aspects of false ureteral passages.**

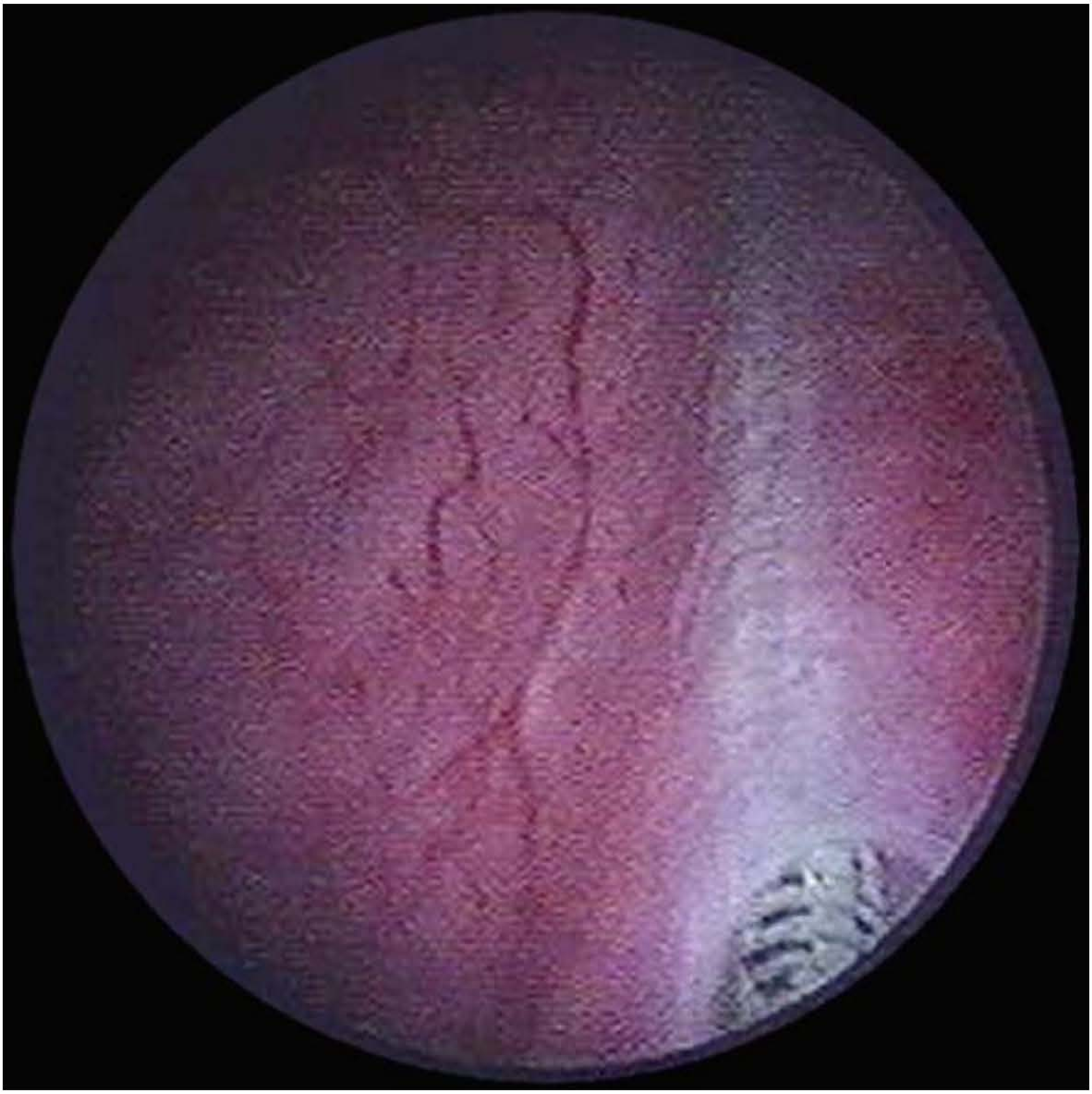

Figure 6.100 **Submucous vesical trajectory produced by the guidewire's insertion.**

Blute et al. (1988) reported a rate of false passages of 0.9% after 346 ureteroscopic procedures, while Grasso (2000) observed an incidence for this complication of 0.4% in a series of 1000 patients. As in the case of perforations, their incidence can be underestimated due to the fact that the lesions are not recognized during the intervention.

Lytton et al. (1987) reported complete occlusion with ureteral necrosis after a false passage along the entire length of the ureter produced during ascension of the ureteroscope.

The appearance of a false passage while placing the guidewire can be suspected when it is difficult or impossible to advance it. If there are any doubts regarding the existence of the ureteral mucosal lesions, contrast media can be injected in order to confirm the position of the guidewire in the pyelocaliceal system. The appearance of periadventitial leakage of the contrast media can verify the existence of the false passage, and the guidewire must be repositioned inside the lumen. Sometimes, this maneuver can only be performed under direct ureteroscopic visual control (Geavlete et al., 2000c) (Fig. 6.101).

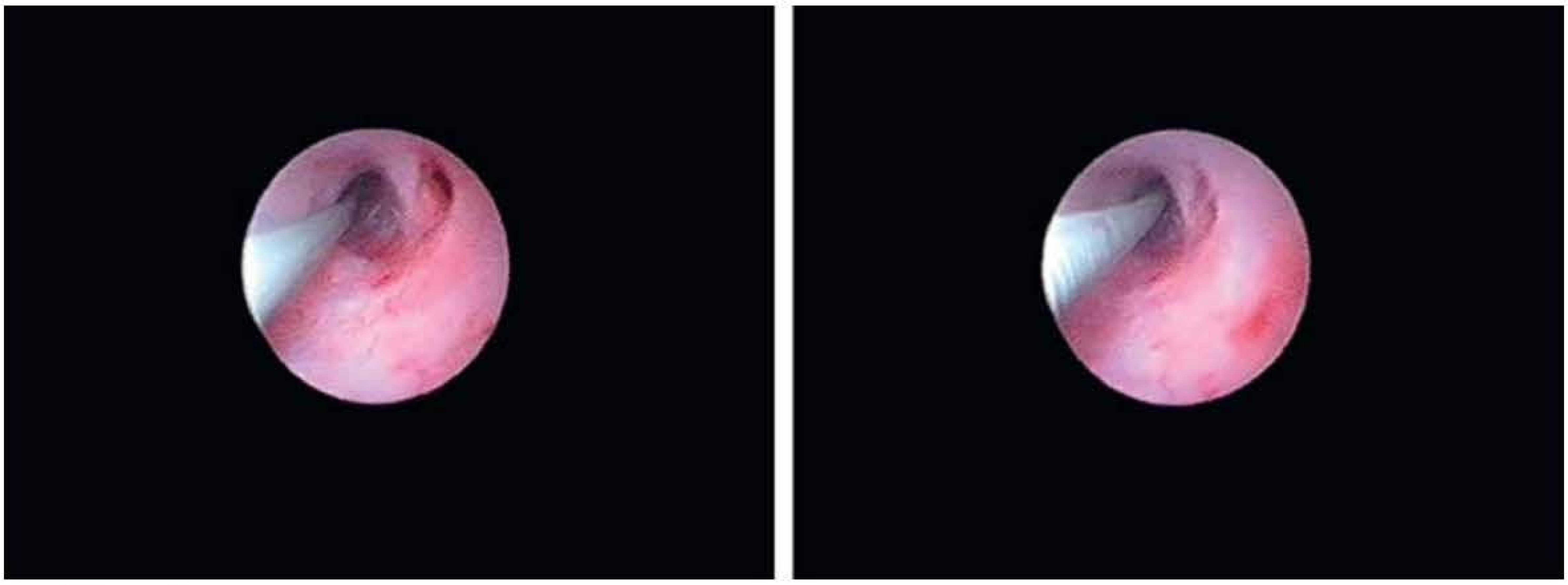

Figure 6.101 **Ascending the guidewire into the ureteral lumen under direct ureteroscopic visual control.**

The ureteral false passages produced during the ascent of the guidewire may lead to severe lesions, when large-caliber working instruments or catheters are subsequently ascended through it.

The sequelae of false passages are usually minor. In most cases, ureteral stenting for 1–2 weeks is sufficient. Small false passages, limited to the mucosa, can be treated conservatively without placing a stent. The important ones may require suppressing the newly formed ureteral septum (Figs 6.102–6.105).

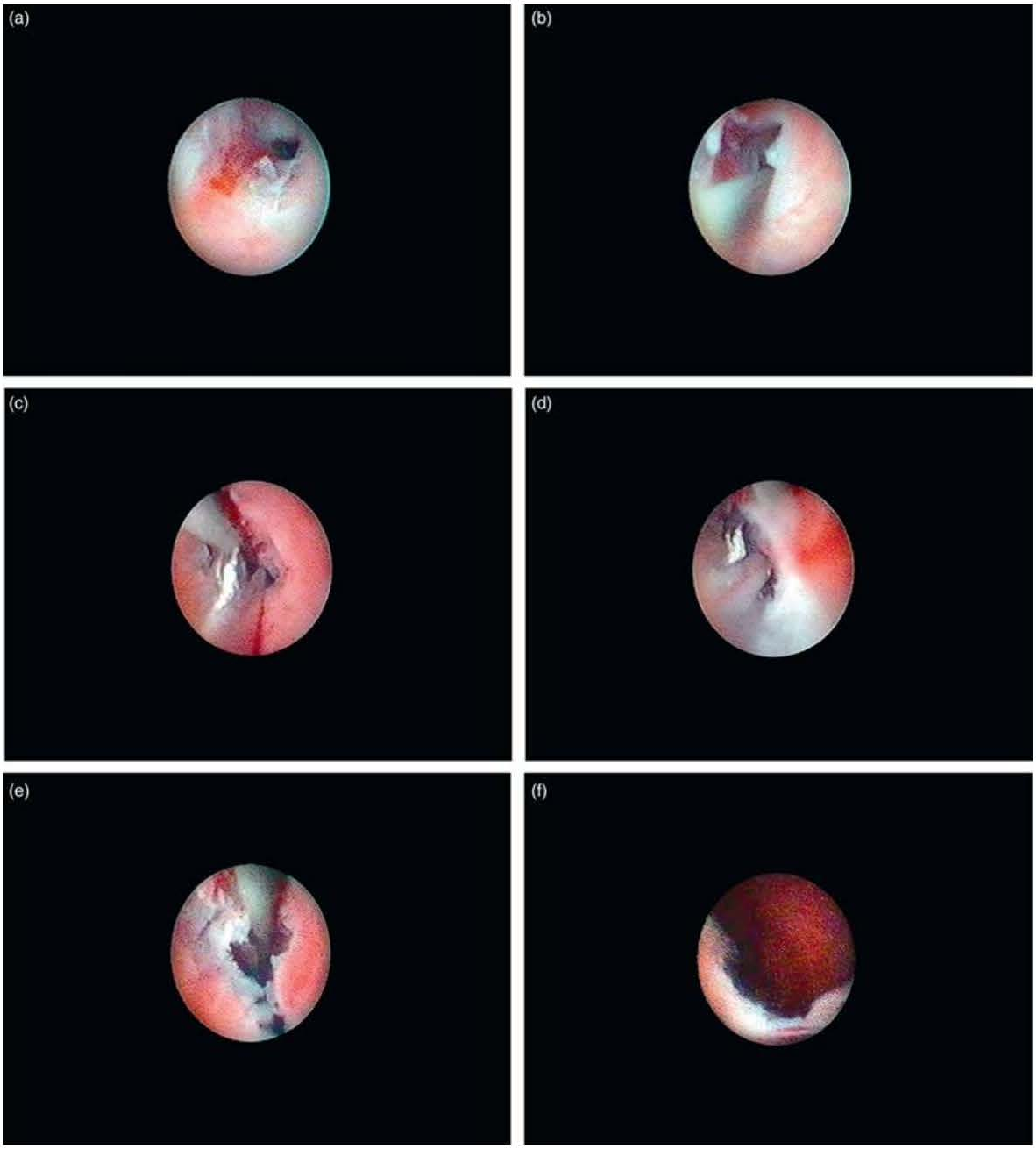

Figure 6.102 The ureteroscopic management of a postureteroscopy false passage (a): insertion of the metallic guidewire into the ureteral lumen (b), cold-knife incision of the ureteral septum (c–e), final aspect of the large ureteral lumen (f).

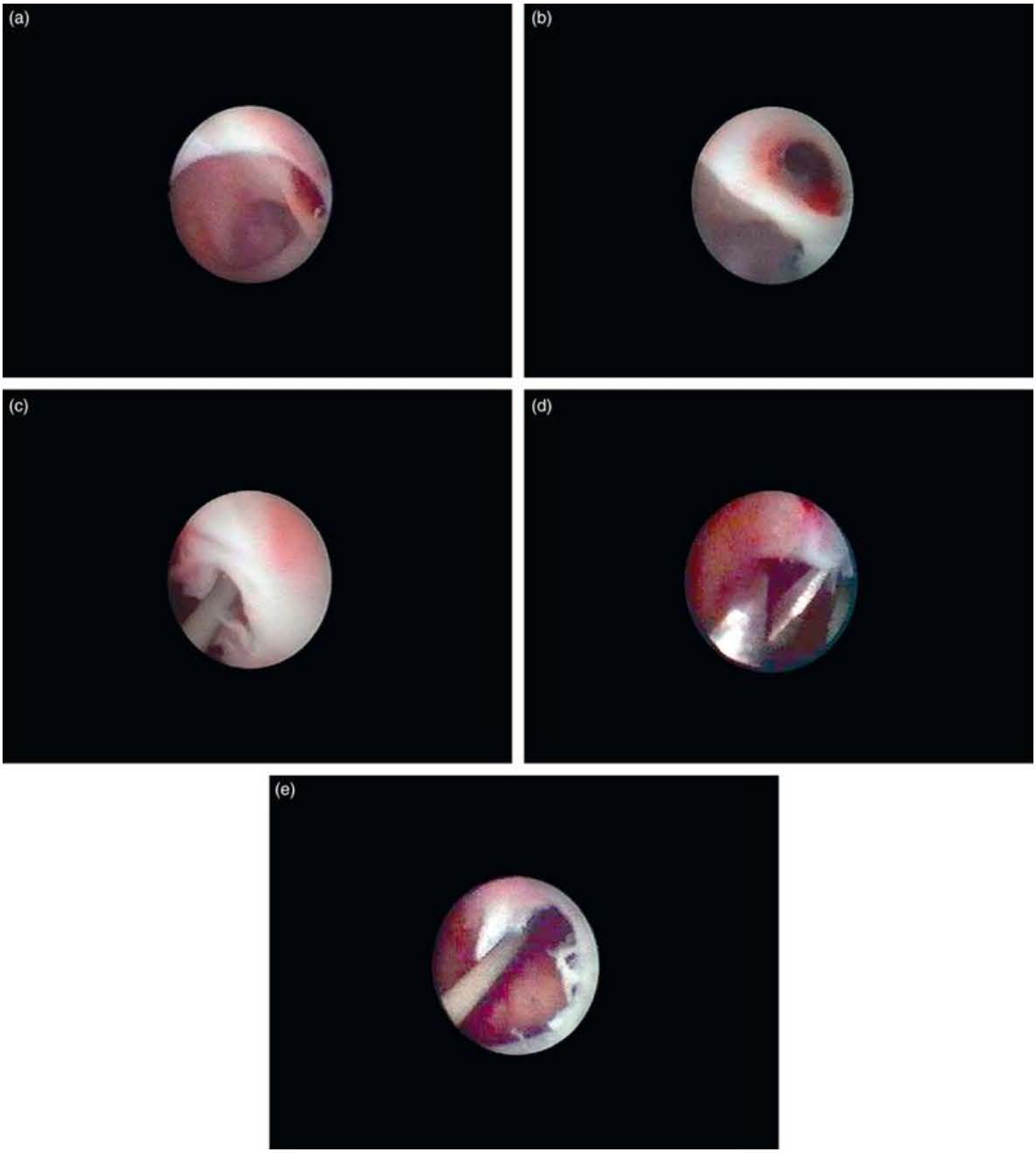

Figure 6.103 Iatrogenic false passage (a, b) treated ureteroscopically: insertion of the metallic guidewire into the ureteral lumen (c), cold-knife incision of the ureteral septum (d), final aspect of the large ureteral lumen (e).

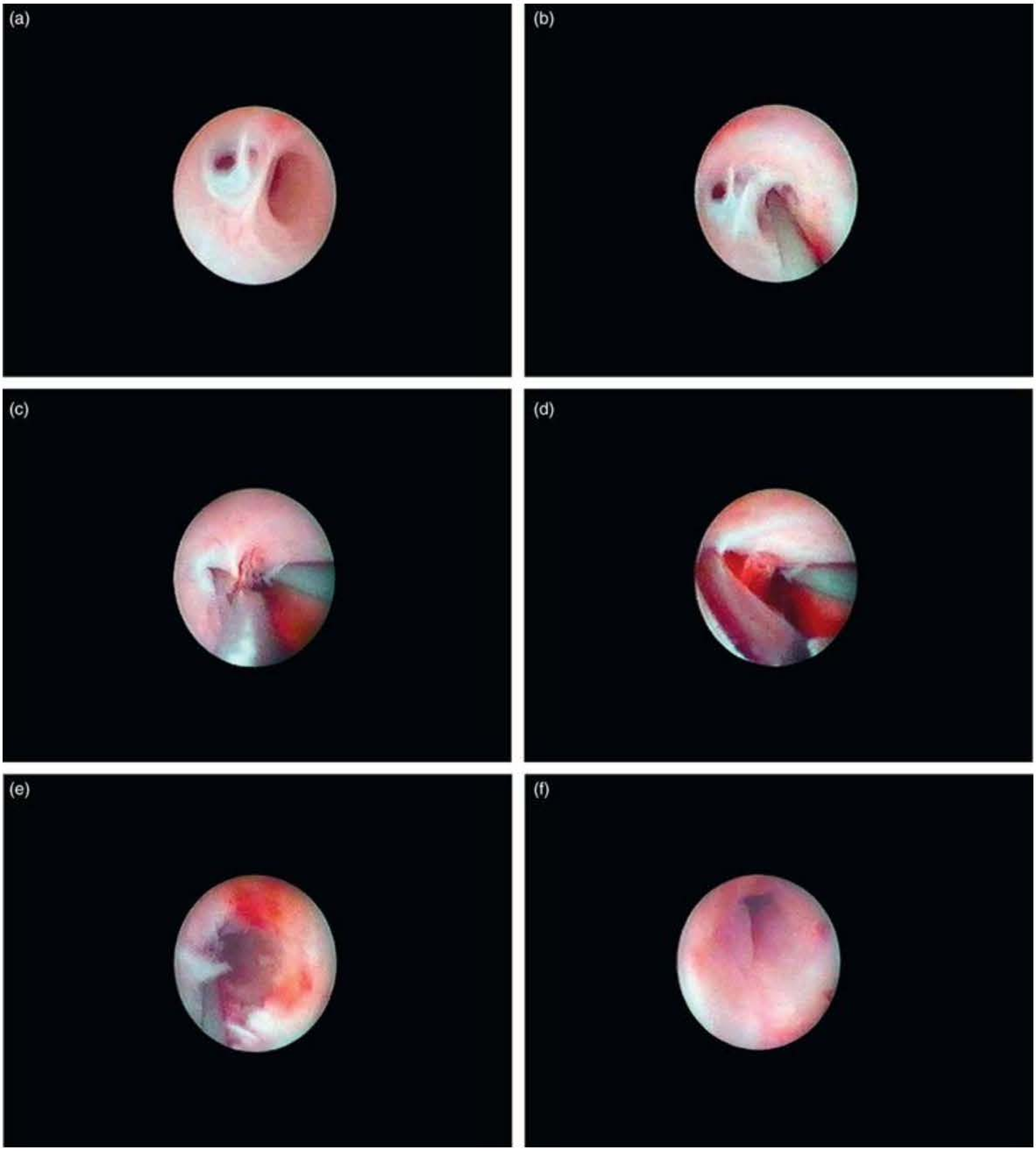

Figure 6.104 Ureteroscopic management of a postureteroscopy false passage (a): insertion of the metallic guidewire into the ureteral lumen (b), cold-knife incision of the ureteral septum (c, d), final aspect of the large ureteral lumen (e), normal ureteroscopic aspect at 6 months (f).

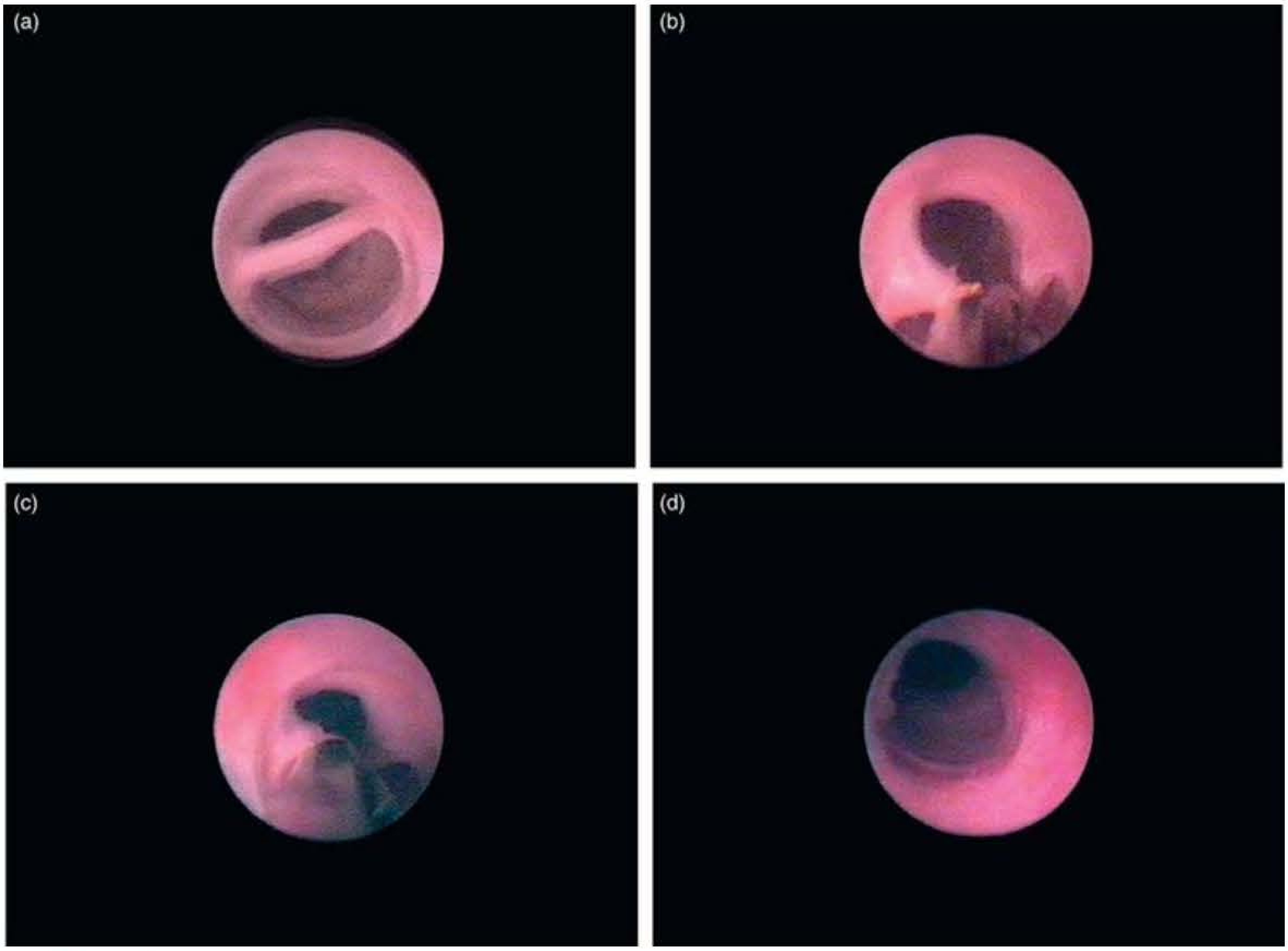

Figure 6.105 Ureteroscopic management of a ureteral septum (a) secondary to an iatrogenic false passage produced 6 months previously: dismantling the septum with a clamp (b, c), aspect of the ureteral lumen at the end of the intervention (d).

6.6.2.3. Bleeding

Bleeding secondary to ureteroscopy is usually minor. It usually occurs as a result of trauma to the ureteral orifice, of lesions produced while ascending the guidewire, of fragmenting, or by manipulating the calculi (Figs 6.106 and 6.107).

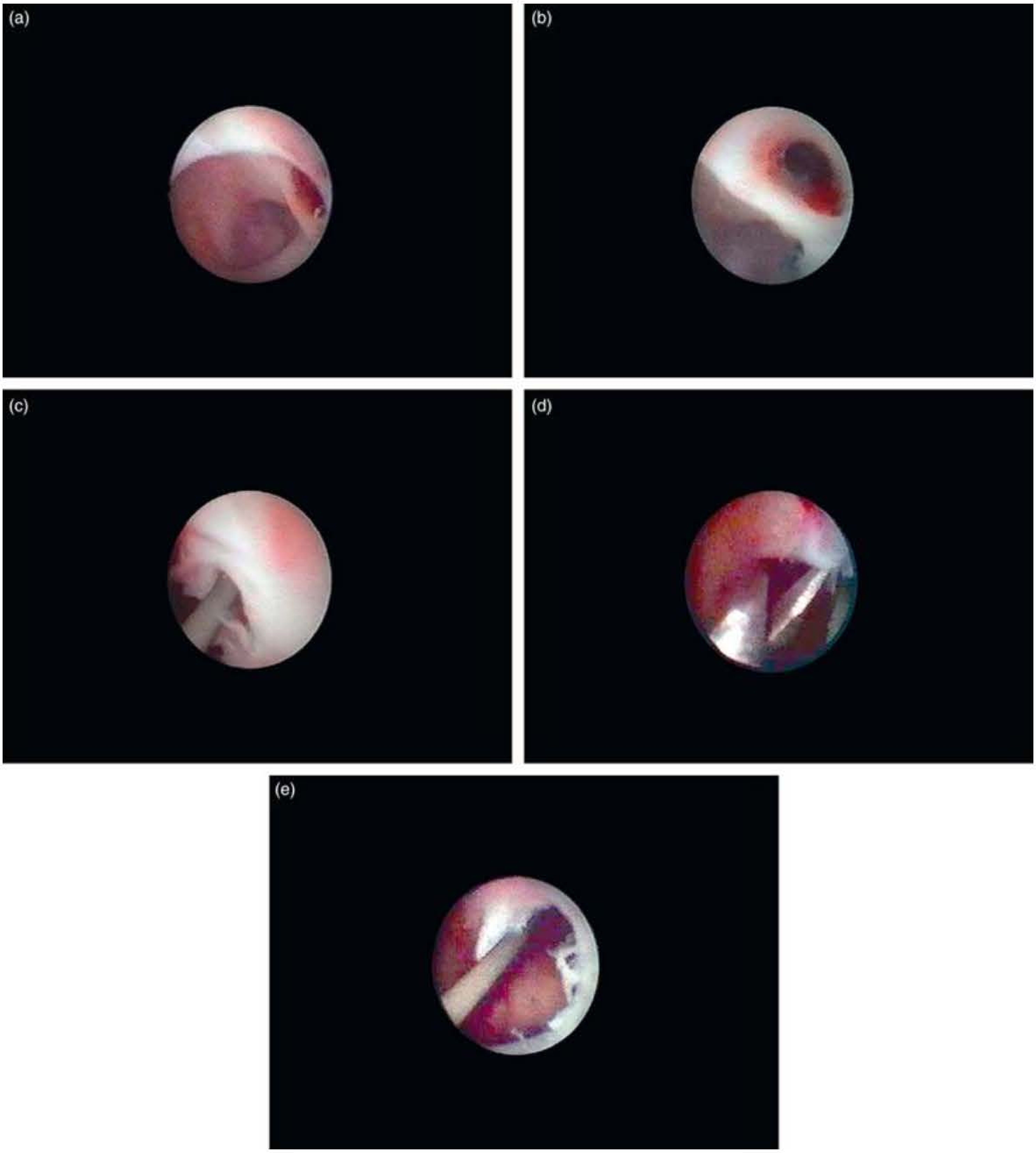

Figure 6.103 Iatrogenic false passage (a, b) treated ureteroscopically: insertion of the metallic guidewire into the ureteral lumen (c), cold-knife incision of the ureteral septum (d), final aspect of the large ureteral lumen (e).

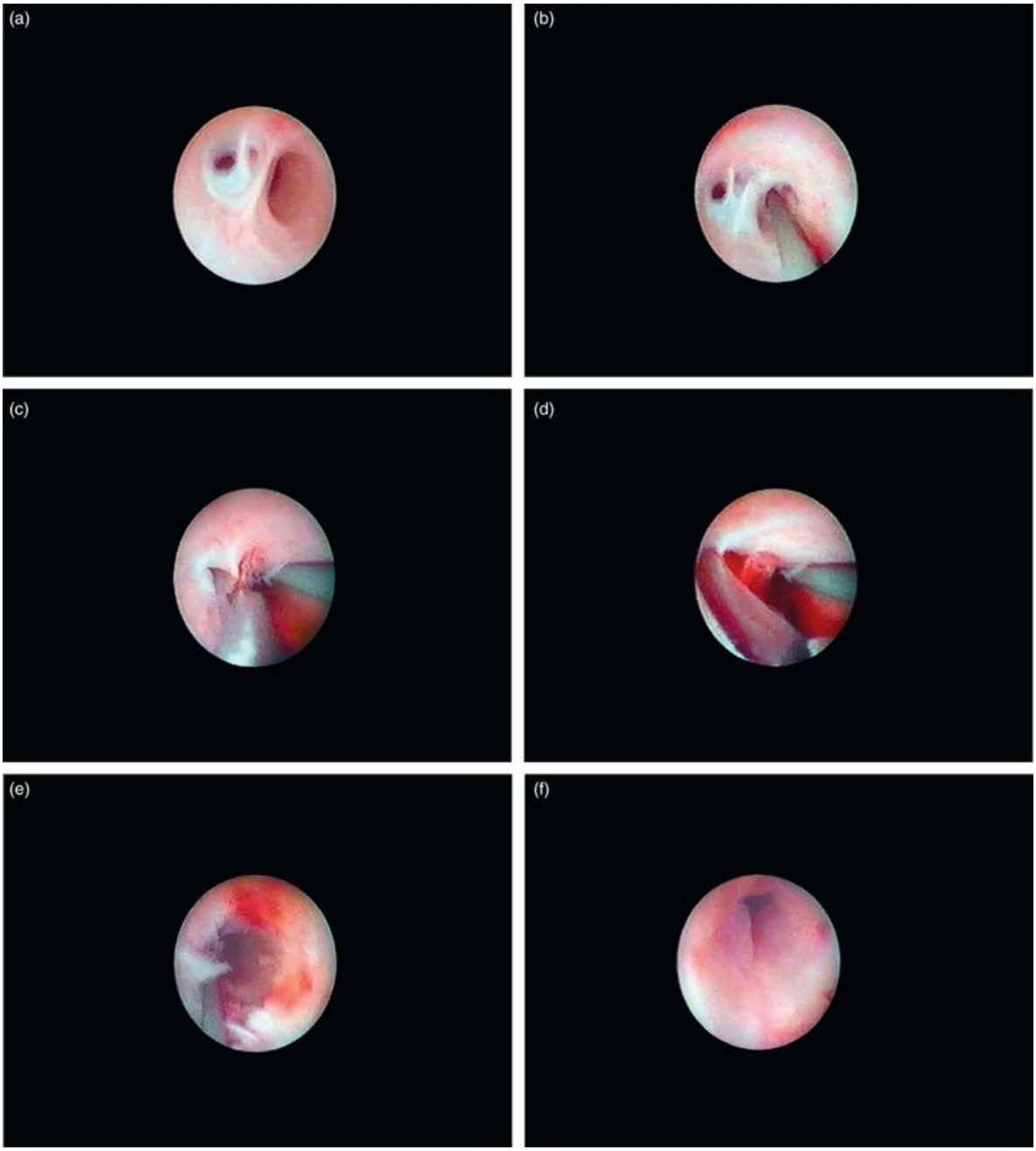

Figure 6.104 Ureteroscopic management of a postureteroscopy false passage (a): insertion of the metallic guidewire into the ureteral lumen (b), cold-knife incision of the ureteral septum (c, d), final aspect of the large ureteral lumen (e), normal ureteroscopic aspect at 6 months (f).

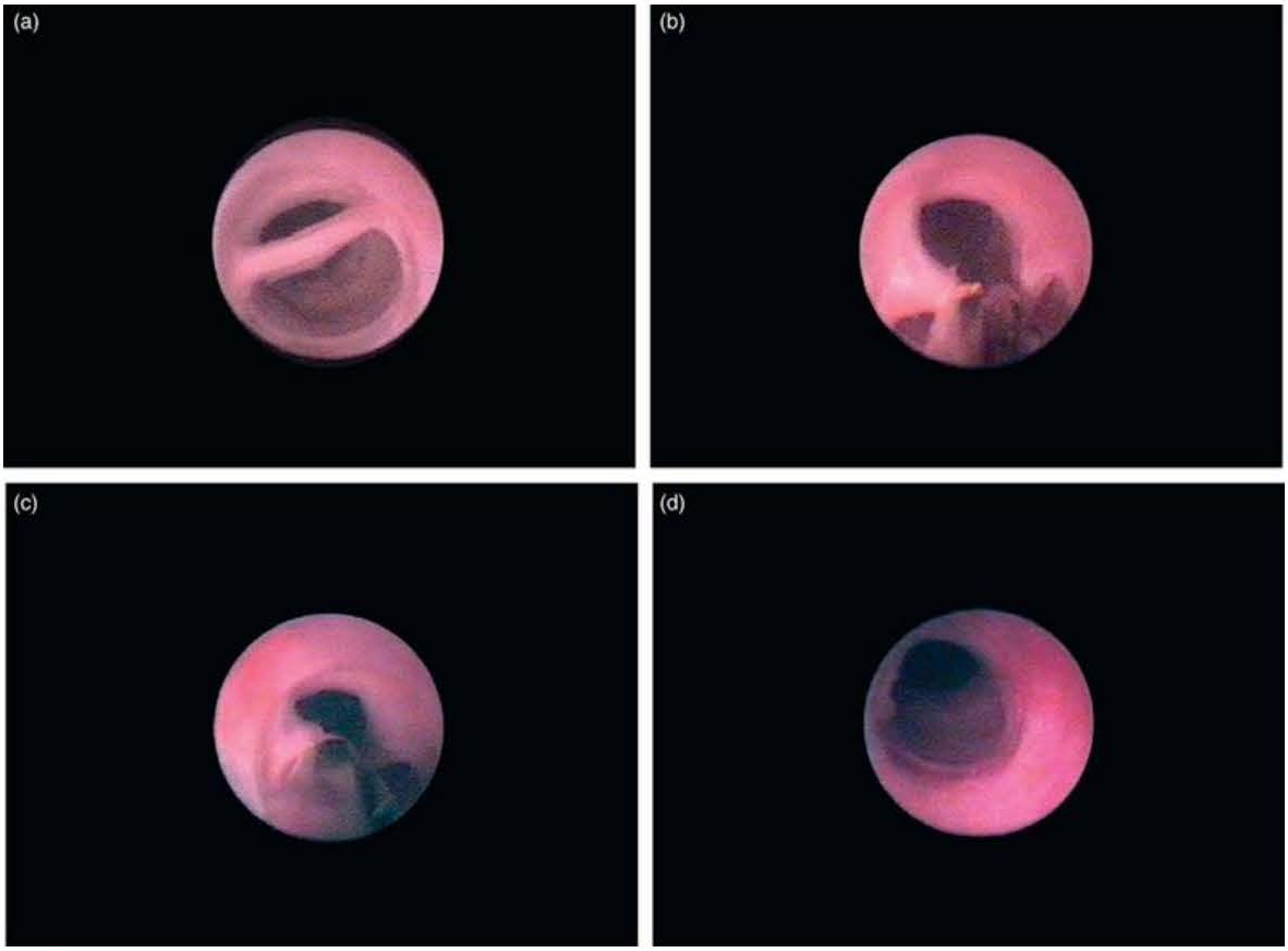

Figure 6.105 **Ureteroscopic management of a ureteral septum (a) secondary to an iatrogenic false passage produced 6 months previously: dismantling the septum with a clamp (b, c), aspect of the ureteral lumen at the end of the intervention (d).**

6.6.2.3. Bleeding

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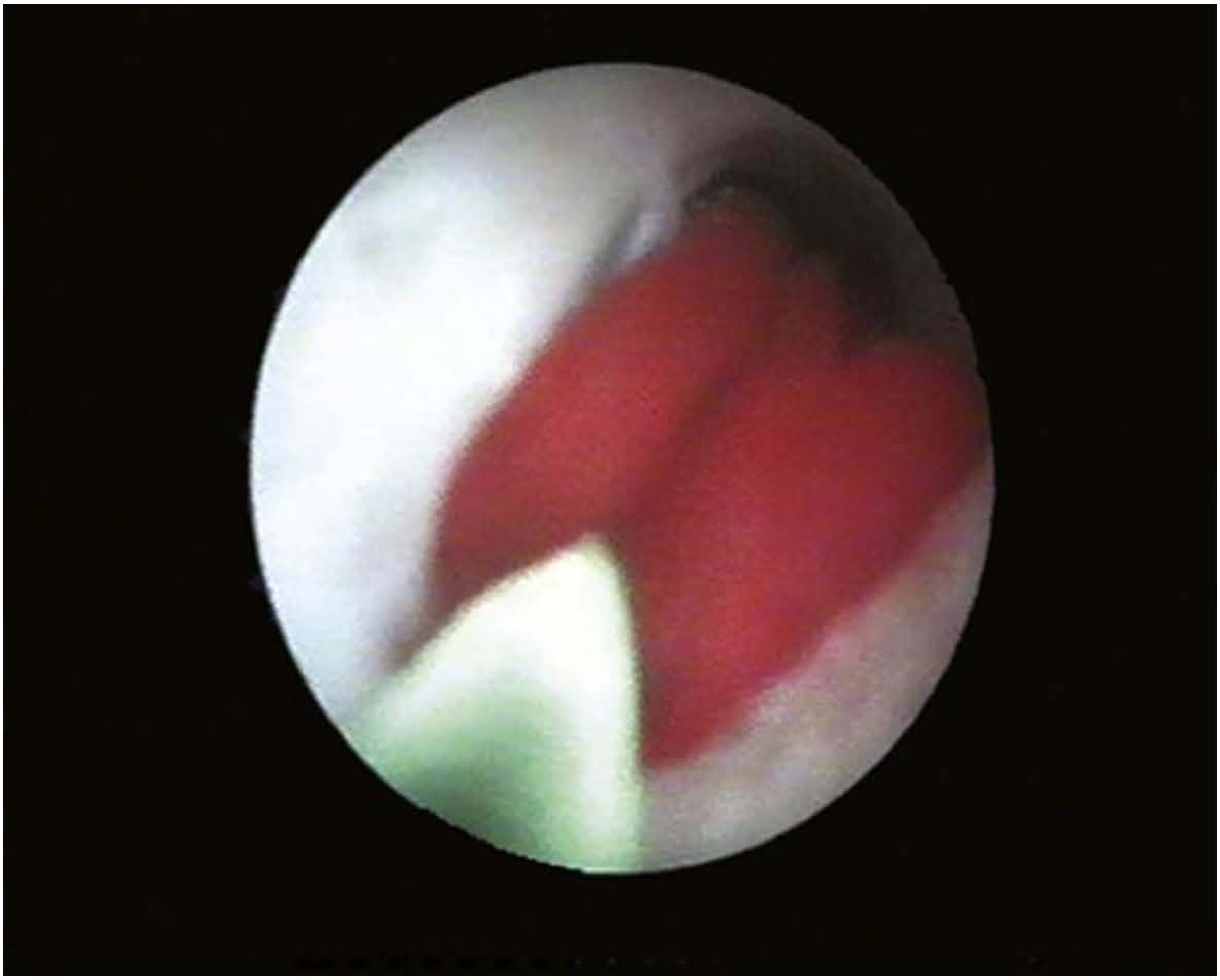

Figure 6.106 **Blood clot adherent to the guidewire.**

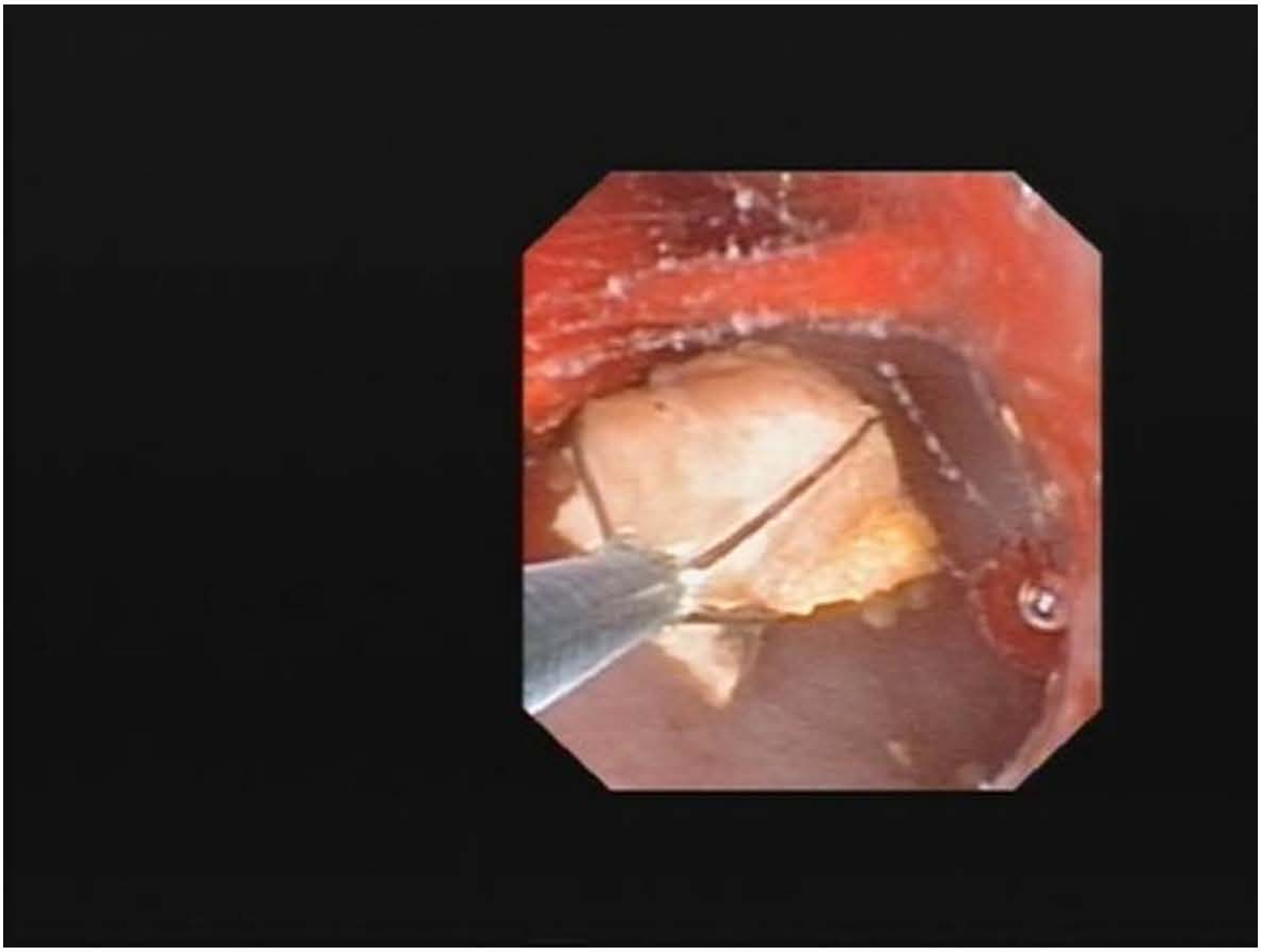

Figure 6.107 **Blood clot adherent around the stone.**

In general, bleeding determines difficulties secondary to the reduction of visibility during the procedure. Very rarely, in the case of major ureteral lesions, the intensity of bleeding may require interrupting the procedure or additional measures for its control.

Blute and coworkers observed that the reduction of visibility secondary to minor bleeding represented the most frequent cause that determined repeating the procedure. However, bleeding represented the primary complication in only 0.3% of cases (Blute et al., 1988). In a group of 290 patients, Abdel-Razak and Bagley (1992) reported an incidence of bleeding that required interrupting the procedure of 2.1%. None of the patients in this group required transfusions.

After 1000 procedures, Grasso (2000) reported rates of 0.8% and 0.2%, respectively, for intraoperative or prolonged postoperative bleeding. The risk of intraoperative bleeding can be reduced by using an adequate technique. Severe bleeding requires interruption of the procedure and placing a ureteral stent in order to facilitate drainage and to prevent the formation of clots.

6.6.2.4. Extraureteral Migration of the Stone or of the Lithiasic Fragments

The incidence of extraureteral migration of the calculi or lithiasic fragments (reported in the literature) varies between 0.5% and 2.3% (Stackl and Marberger, 1986; Weinberg et al., 1987; Flam et al., 1988).

Extraureteral migration of the stone (Fig. 6.108) does not usually determine clinical complications and does not require treatment (Kriegmair, 1995). On the other hand, the presence of a discontinuity of the ureteral wall may determine the occurrence of a stenosis or of other late complications.

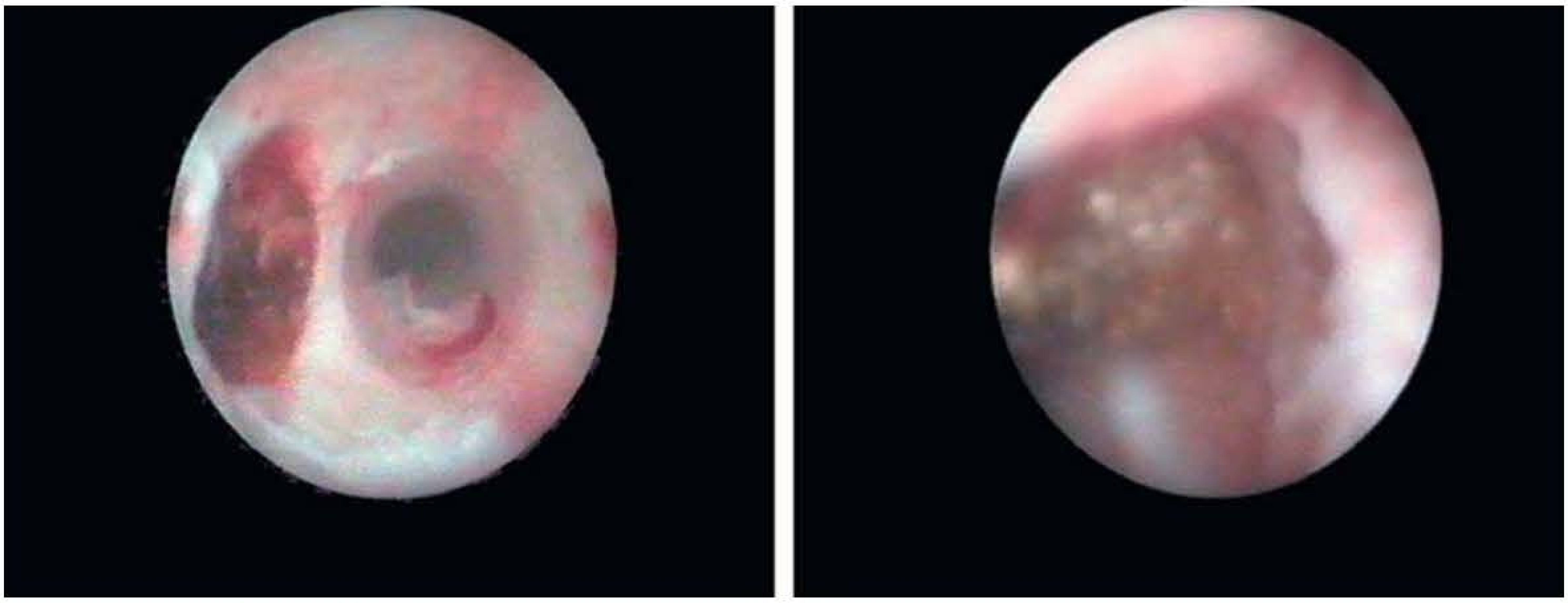

Figure 6.108 **Lithiasic fragment migrated at the level of a ureteral perforation.**

The attempt to advance the ureteroscope or to insert different instruments through the breach in order to extract the lithiasic fragments may enlarge the ureteral wall defect. A retroperitoneal abscess may occur in cases of lithiasis associated with urinary infection.

The extraureteral migration of the stone requires radiological localization of the fragments and informing the patient in order to avoid any future diagnostic confusion (Evans and Stoller, 1993) (Fig. 6.109). Postoperatively, ultrasonographic surveillance is recommended in order to check for the absence of obstruction and of repercussions on the overlying urinary tract.

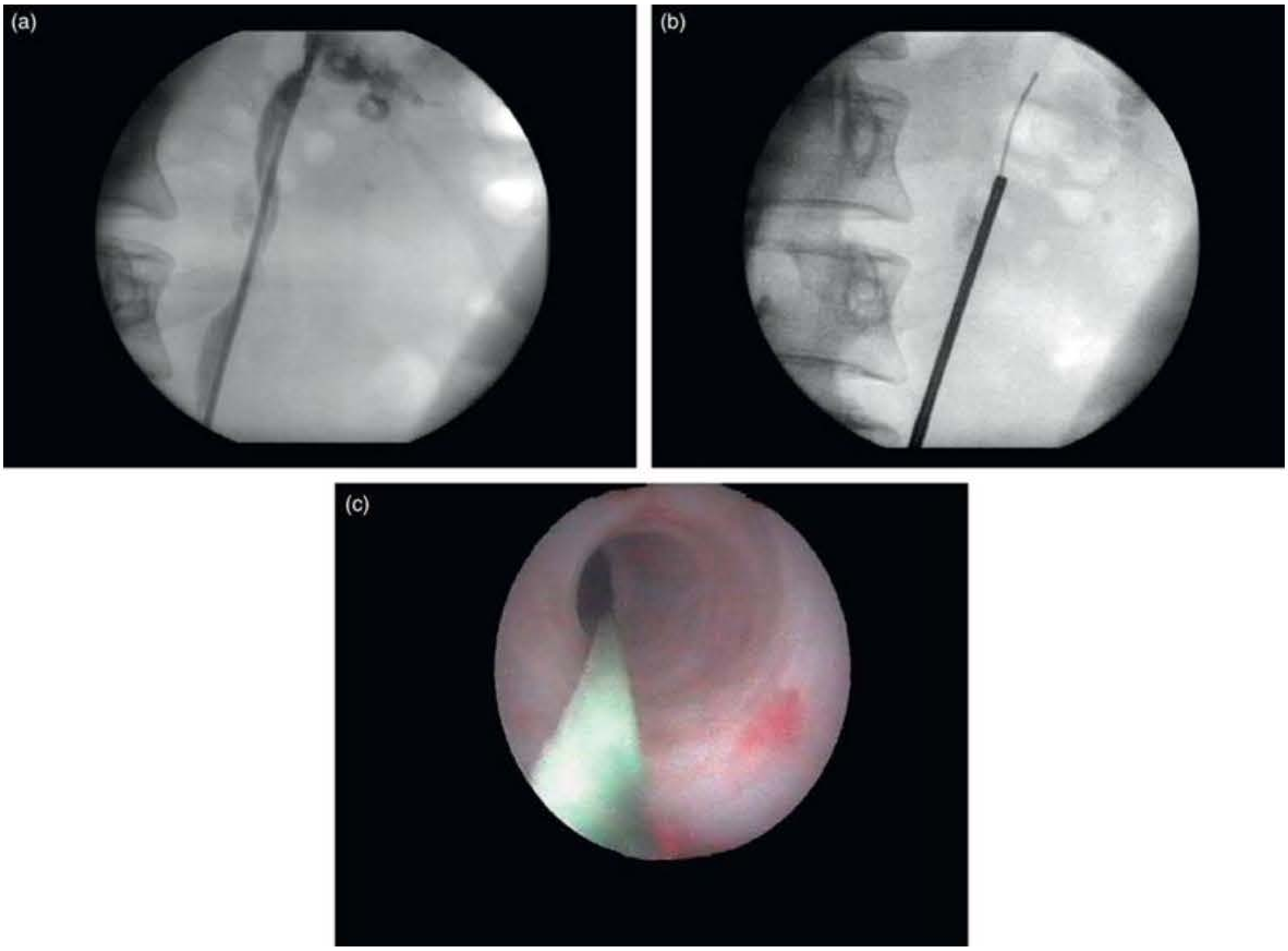

Figure 6.109 **Lithiasic fragments migrated outside the ureter.**

Intraoperative fluoroscopic aspect (a, b), normal aspect of the lumen at 3 months after ureteral perforation with migration of the calculi (c).

6.6.2.5. Migration of the Lithiasic Fragments at the Submucous Level

The migration of the lithiasic fragments at the level of the ureteral submucosa represents a complication for which choosing the therapeutic attitude represents a controversial issue. Although exteriorization of a lithiasic fragment through the ureteral wall does not generate long-term consequences, its fixation at the submucous level can determine formation of granulomas with consecutive appearance of ureteral stenoses. Extraction of these calculi is difficult (Fig. 6.110), and may lead to ureteral perforation with retroperitoneal urinoma and secondary periureteral fibrosis.

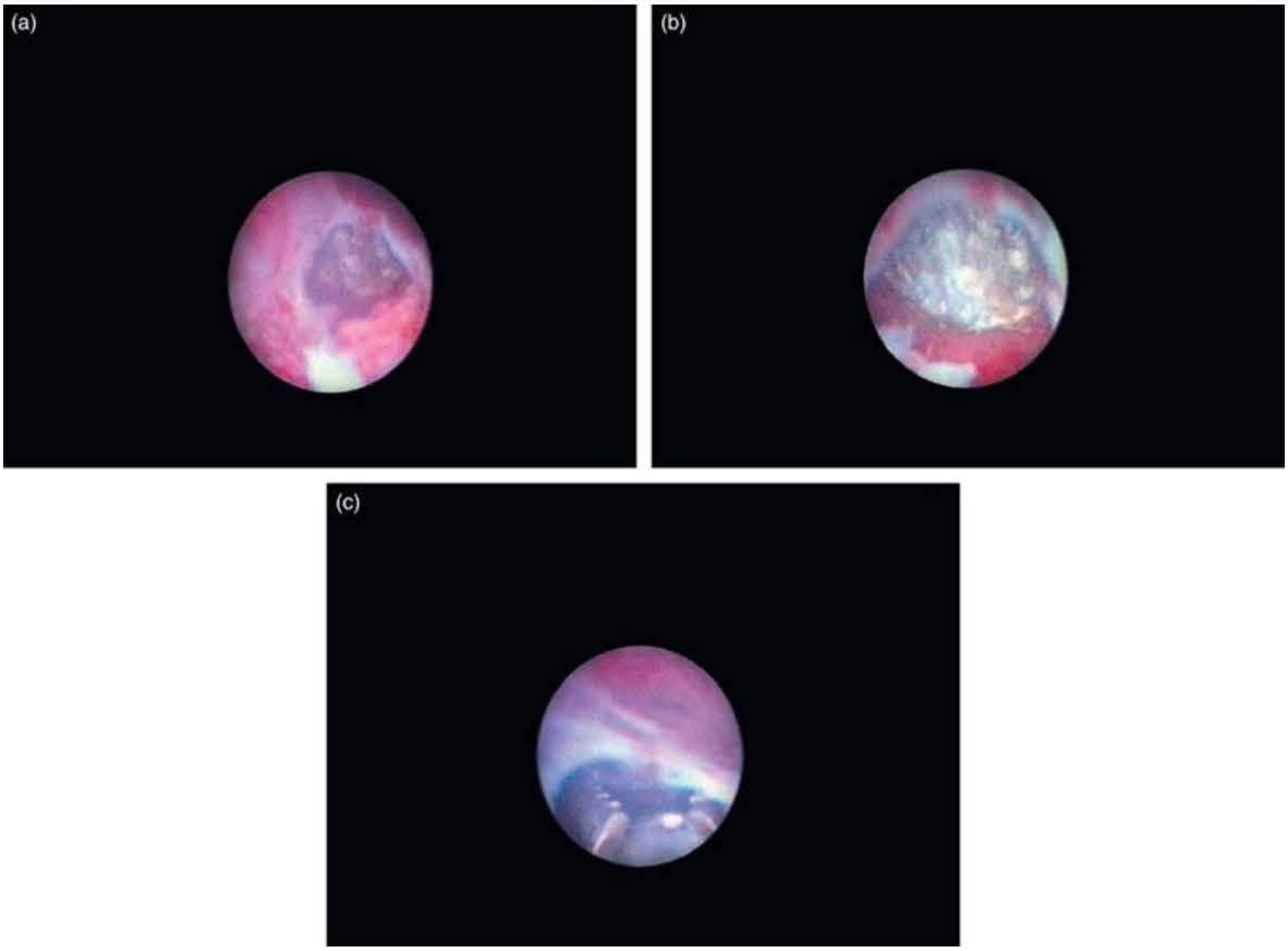

Figure 6.110 **Lithiasic fragment migrated to the submucosal level (a, b), extracted with a clamp (c).**

Dretler and Young (1993) reported four cases of granuloma determined by calcium oxalate lithiasic fragments embedded in the ureteral wall during ureteroscopic lithotripsy, detected in a series of patients with stenoses that could not be treated by ureteral dilation.

Grasso et al. (1995c) underlined an increased risk of occurrence of stenoses in the case of lithiasic fragments embedded in the ureteral wall less than 4 mm from the lumen. For this reason, the authors recommend assessment by endoluminal ultrasonography, suggesting that fragments located less than 4 mm from the lumen should be extracted, while fragments located more profoundly may be left in place with a minimal risk of future sequelae. In many cases, the fragments located at the submucosal level can be detected endoscopically as a prominence of the ureteral wall without requiring endoluminal ultrasonography. Calculi impacted in the submucosa can be extracted by laser excision, followed by prolonged ureteral stenting. If this is not possible, surgical resection of the affected ureteral segment is necessary.

When the obstruction occurs after the intervention, the CT scan can demonstrate the presence of lithiasic fragments in the vicinity of the ureteral lumen or along the stent.

6.6.2.6. Urinary Leakage

Urinary leakage may occur as a result of ureteral wall or renal pelvic lesions (Fig. 6.111) and leads to retroperitoneal urinoma. The incidence of urinary leakage ranged between 0.6% and 1% in different studies, but due to the fact that routine intraoperative retrograde pyelography is not recommended, it is possible that the true incidence of this complication is underestimated. The degree of leakage is directly related to the dimensions of the parietal lesions and the moment when the perforation takes place.

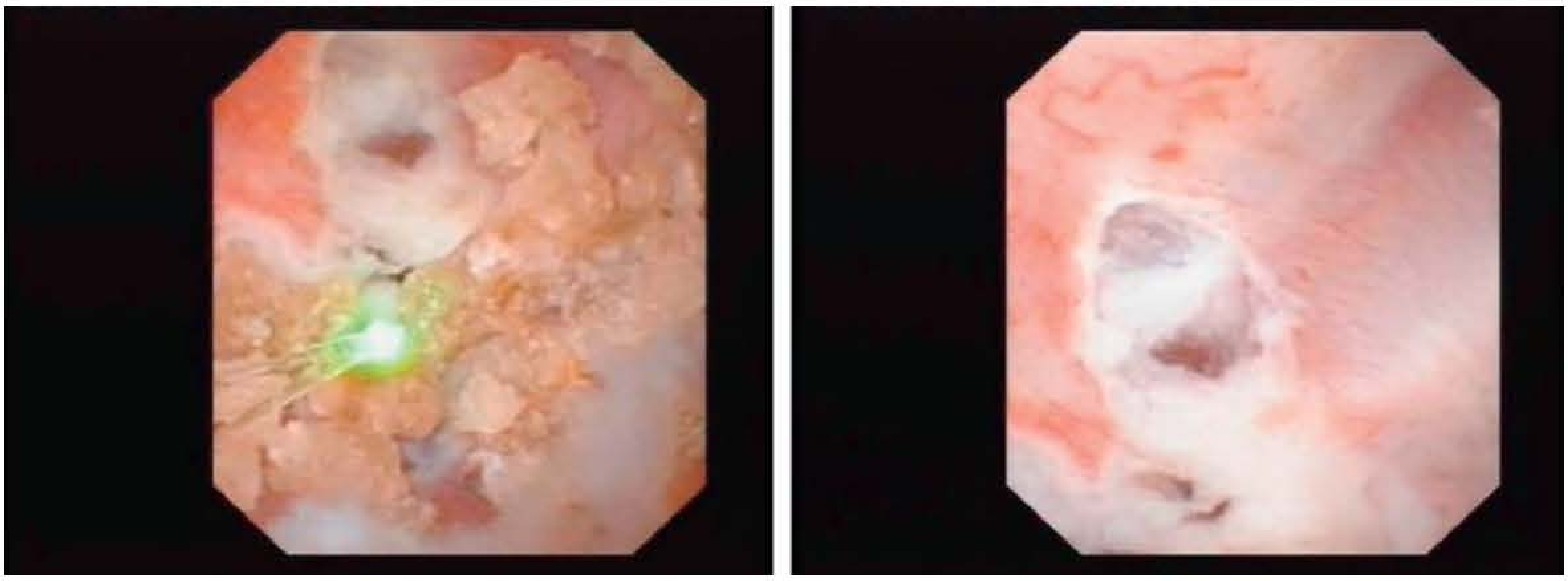

Figure 6.111 **Urinary tract perforation after Ho:YAG laser lithotripsy.**

The leakage of small amounts of fluid does not usually have clinical consequences. However, important leakages can have unfavorable effects. The absorption of hypotonic irrigation fluid can lead to volemic overload, hyponatremia, and hemolysis. The use of saline solutions during ureteroscopy can prevent this complication. The use of an adequate irrigation pressure is recommended for avoiding caliceal perforations or ruptures.

The presence of an associated urinary infection can determine the appearance of retroperitoneal abscesses. Some studies have demonstrated that urinary leakage is at the origin of periureteral fibrosis. In case of important leakage, ureteral endoprosthesis or percutaneous nephrostomy can ensure an adequate drainage and healing without sequelae.

When urinary leakage is suspected postoperatively, exploration by intravenous urography is required. The value of spiral CT without contrast media is currently under assessment.

6.6.2.7. Thermal Lesions of the Ureteral Mucosa

The use of accessory instruments during ureteroscopy that generate heat can determine damage to the adjacent tissues, with lesions varying from small mucosal defects (Fig. 6.112) to large areas of necrosis. Thus, the Nd:YAG laser, with a penetrability of 5–6 mm, must be used carefully, to reduce the risk of injuring the adjacent organs (Chen and Bagley, 2001). The electrohydraulic lithotripter is associated with a significant increase of temperature and determines a high risk of ureteral lesions (Huffman, 1989). Basar et al. (1997) reported two perforations (1%) produced by electrohydraulic lithotripsy in a series of 207 ureteroscopic procedures. The energy generated by the Ho:YAG laser is absorbed by water, creating thermal lesions over a distance of 0.5–1 mm (Wollin and Denstedt, 1998). In a study that analyzed 598 flexible ureteroscopic procedures, Sofer et al. (2002) reported four complications that could be attributed to the use of the Ho:YAG laser, of which one was a ureteral perforation and three were fragmentations of the laser fiber. Although thermal lesions can only be treated by ureteral stenting, they have the potential for determining late complications (Flam et al., 1988). Thermal lesions can be prevented by avoiding contact of the probe with the ureteral mucosa and by positioning it parallel to the wall.

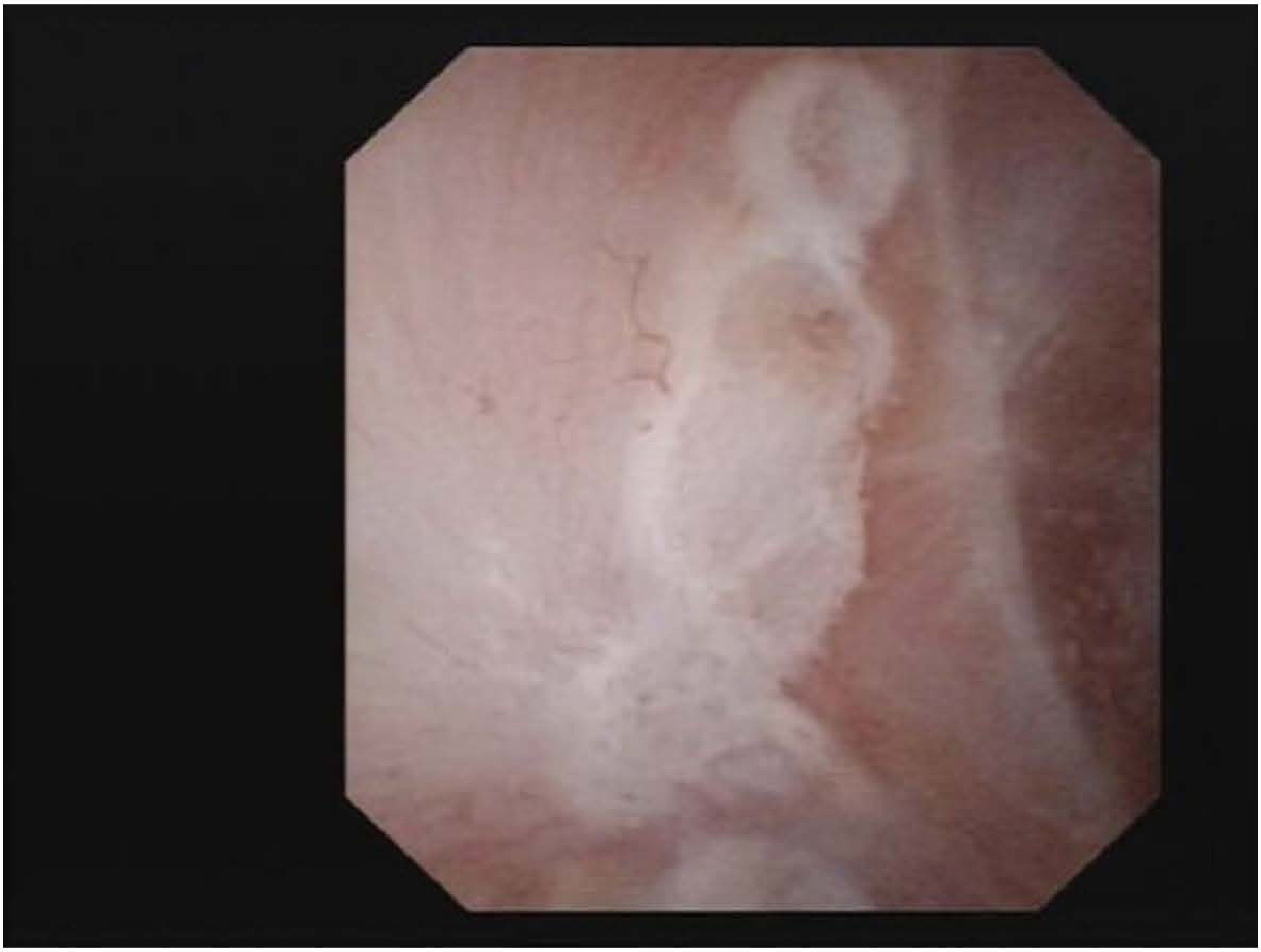

Figure 6.112 **Minimal thermal lesions of the caliceal mucosa after Ho:YAG laser lithotripsy.**

6.6.2.8. Injury of the Intramural Ureter

The injury of the intramural ureter that is too narrow (Fig. 6.113) frequently allows for continuing the ureteroscopy by identifying the lumen and ascending a ureteral catheter under direct visual control through which the endoscope is then advanced. If this maneuver fails, a percutaneous nephrostomy is recommended.

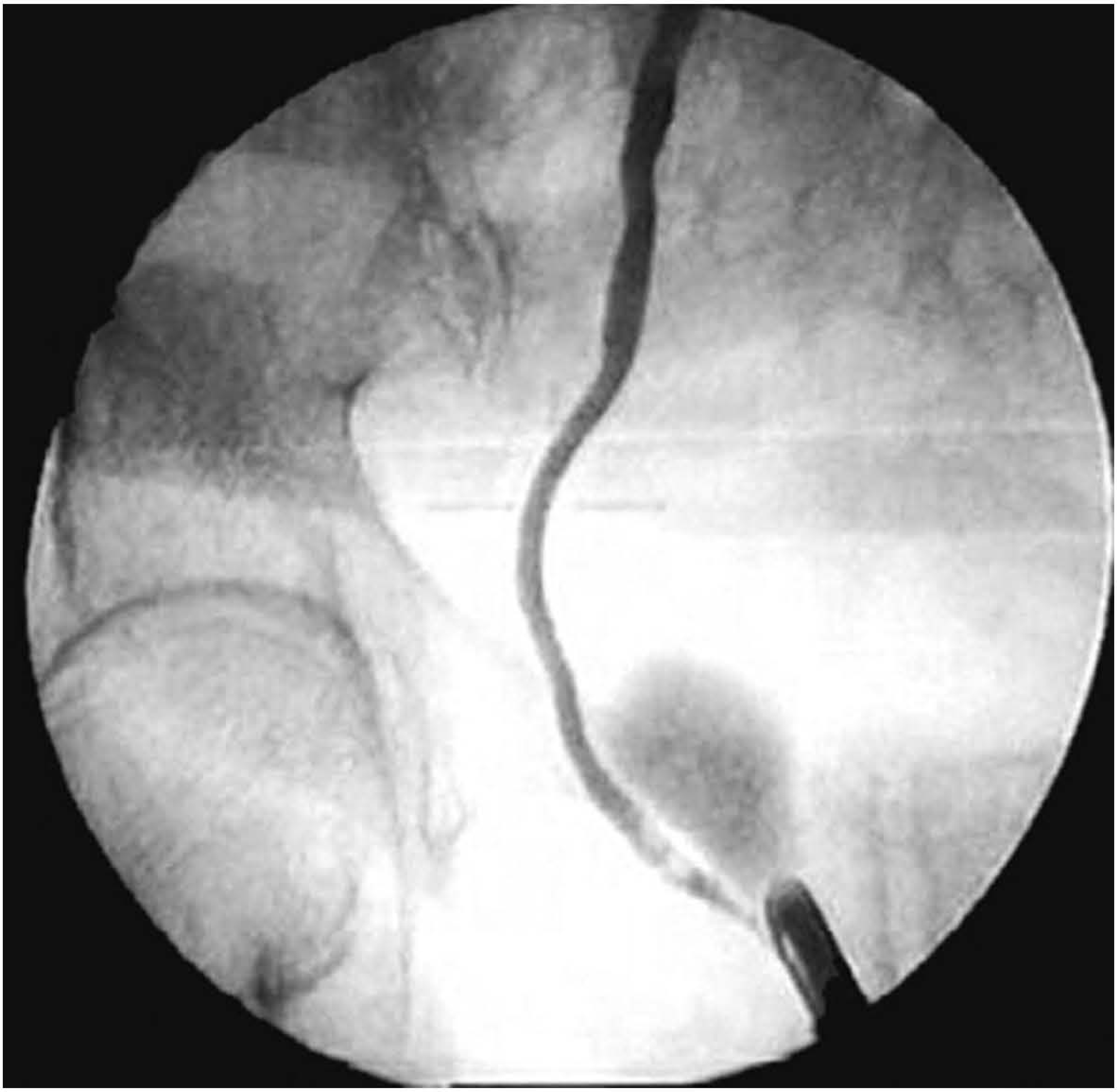

Figure 6.113 **Perforation of the intramural ureter (intraoperative fluoroscopy).**

6.6.2.9. Perforation of the Upper Urinary Tract

Perforations (Figs 6.114 and 6.115) include small lesions that occur while ascending the guidewire, the laser fibers, or other accessory instruments, to important lesions determined by the tip of the ureteroscope or by propulsion of the stone into the ureteral wall.

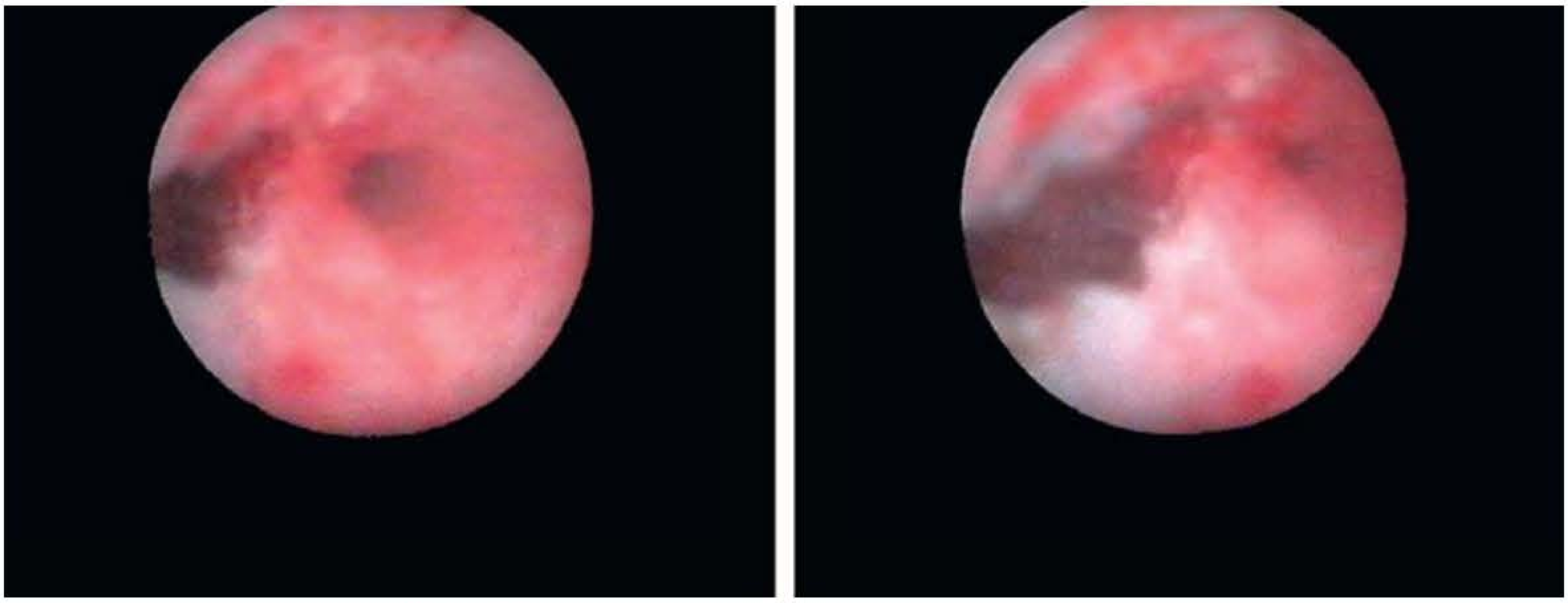

Figure 6.114 Iatrogenic perforation of the ureteral wall.

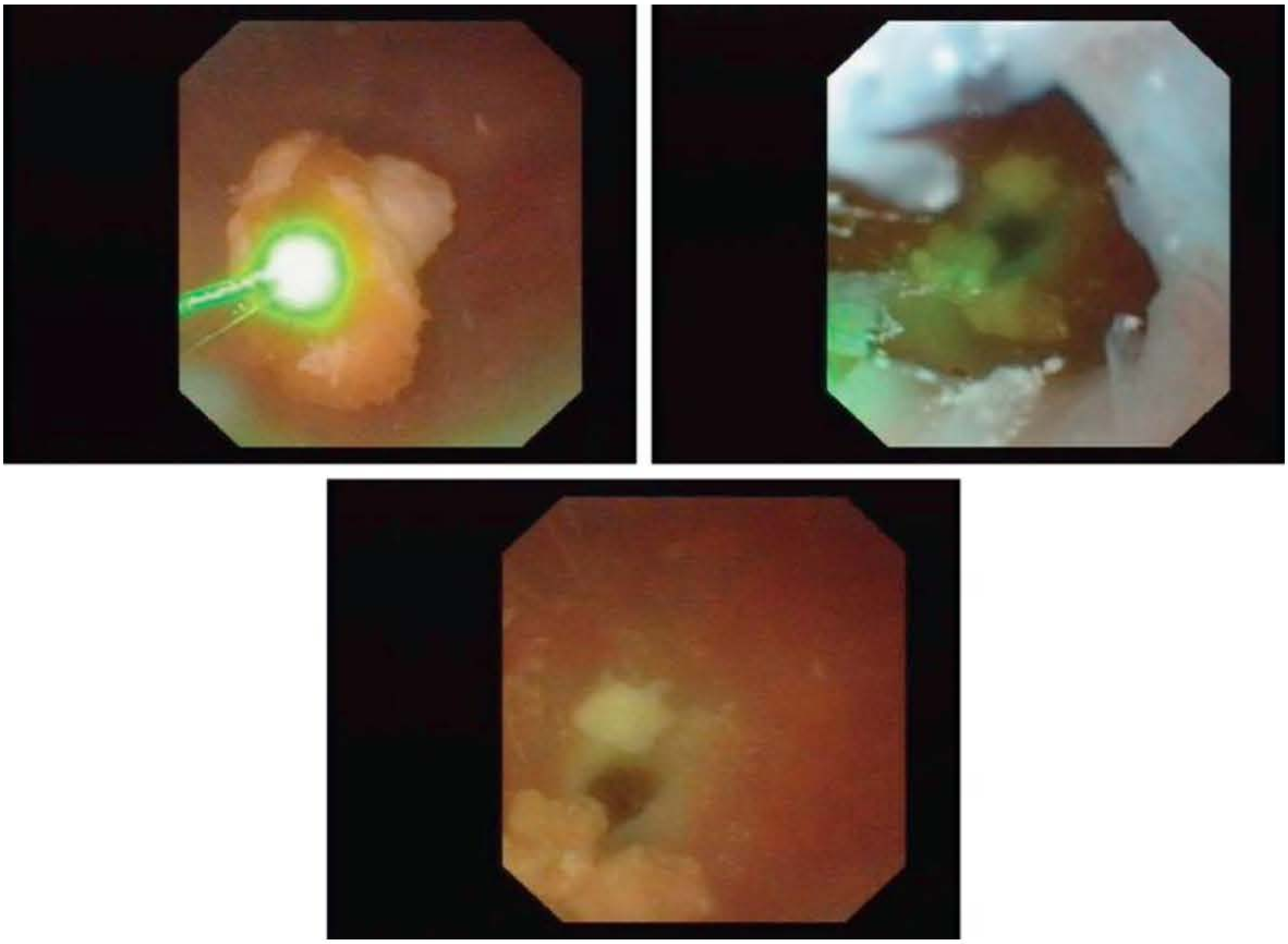

Figure 6.115 Caliceal perforation after Ho:YAG laser lithotripsy.

The incidence of ureteral perforation has decreased after the introduction of small-caliber ureteroscopes and of lithotripters with a more accurate release of energy, as well as with the increase of the experience gained. Thus, the use of laser and pneumatic lithotripters has led to a decrease in the risk of ureteral perforation compared to older-generation electrohydraulic ones. However, ureteral perforation continues to represent a significant complication, implying an important risk of ureteral stenoses.

Assessing the studies published between 1984 and 1992, including 5117 ureteroscopic procedures, Stoller and Wolf (1996) observed an incidence of ureteral perforations of 6.1%. The technical advances and improvement of the ureteroscopes design has led to a significant reduction in the rate of this complication.

In an initial series, Stoller et al. (1992) observed 24 perforations after 156 procedures (15.4%), 19 of them occurring in patients in whom large-caliber ureteroscopes were used (12.5 F). In contrast, Abdel-Razzak and Bagley (1992), using

8.5–10.8 F ureteroscopes, reported a rate of ureteral perforations of 1.7%.

Comparing the results of using conventional ureteroscopes (9.5–11.5 F) with those of small-caliber ureteroscopes (6–7.5 F), Francesca et al. (1995) observed perforation rates of 11.2 and 2%, respectively.

Recent studies have shown an incidence of less than 2% for this complication (Johnson and Pearle, 2004). Grasso (2000) reported the absence of ureteral perforations in a series of 1000 ureteroscopic procedures. The proper use of laser probes, placing them in direct contact with the stone, without involving the mucosa, ensures the prevention of lithotripsy-induced lesions. The differentiation between large perforations and partial avulsions is difficult, while the treatment is in great measure similar. In most cases, ureteral perforation requires stenting for 3–6 weeks. In exceptional situations, ureteral perforation may require open or laparoscopic surgical intervention. In a group of 1575 patients, Jeromin and Sosnowski (1998) reported 29 ureteral lesions. Of these, 20 were represented by minor lesions of the ureteral mucosa, five by minimal perforations that only required ureteral stenting, and four cases with severe perforations that underwent open surgical intervention.

The lesions of the ureteral wall are frequently underestimated, being located especially at the ureterovesical junction, and may be complicated by a false passage. The intramural and supravesical ureter has a more important muscular support than the proximal ureter or the renal pelvis. Also, the cellular layers of the mucosa are more numerous in the lower ureter (3–5) compared to the upper one and the renal pelvis. For this reason, complete perforation of the intramural or distal ureter is less probable than of the proximal one or the renal pelvis.

The risk of ureteral perforation increases in case of sinuosity, of periureteral fibrosis (postsurgical or postirradiation), of an impacted stone, or due to unexpected movements of the patients. General anesthesia is preferred to loco-regional anesthesia in these patients, and especially an adequate curarization of patients is necessary.

Perforation is recognized by observing the breach or the periureteral fat. The careful manipulation of the ureteroscope under visual control may limit the frequency of these traumas.

Schuster et al. (2001) studied the predictive factors of ureteroscopic complications. Using bivariate statistical analysis in a group of 320 cases, they noted a significant association of ureteral perforation with prolonged operative time. Initially, a correlation between the risk of perforation and the stone's location, duration of intervention, and reduced experience of the surgeon was observed. However, after multivariate statistical analysis, only the prolonged duration of the intervention had statistical significance.

Most perforations detected during the procedure can be successfully treated by ureteral stenting for 2–6 weeks (Butler et al., 2003). If ureteral stenting is not possible, percutaneous nephrostomy or antegrade placing of the stent may be required. In case of the impossibility of a retrograde or percutaneous approach, open surgical intervention is necessary.

A close surveillance of patients after the intervention is recommended in order to detect any ureteral stenoses or fistulas secondary to iatrogenic lesions (Fig. 6.116).

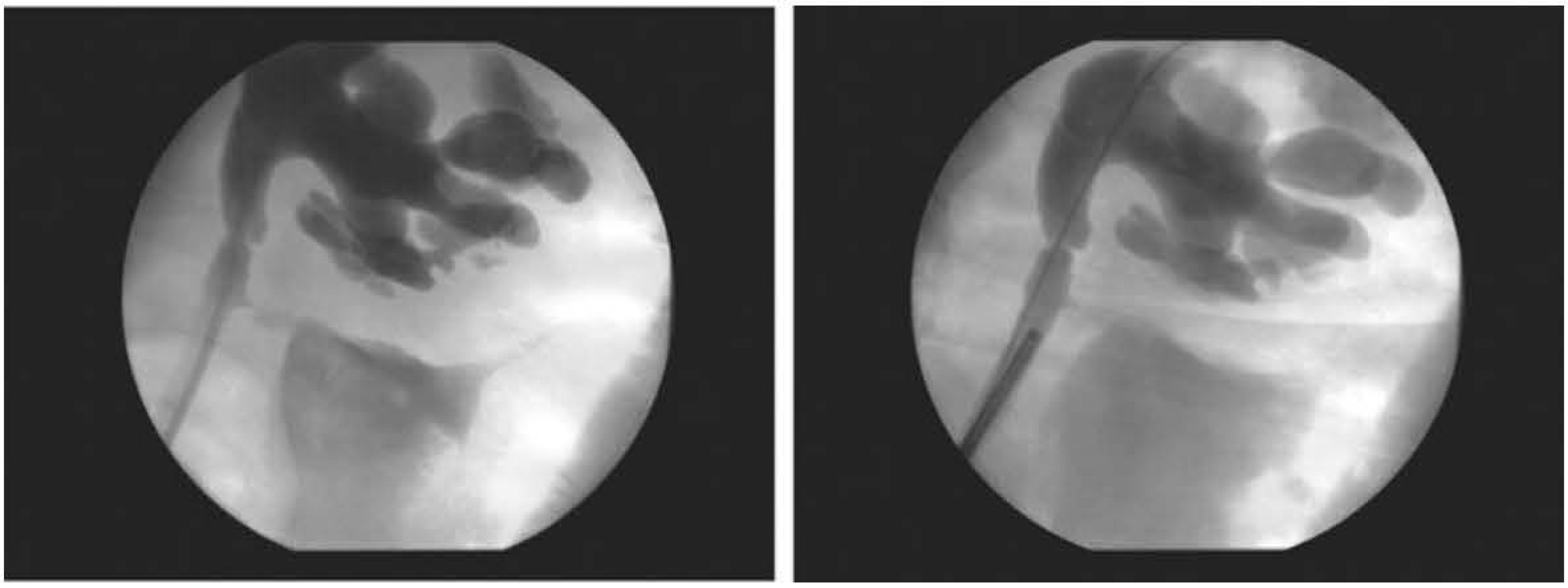

Figure 6.116 **Postoperative iatrogenic uretero-cutaneous fistula (retrograde pyelography).**

6.6.2.10. Ureteral Avulsion

Ureteral avulsion was classically defined as a lesion of the upper urinary tract determined by closed ureteral traumas, the mechanism of appearance being represented by sudden acceleration and deceleration, respectively. With the development of endourology, this term has been used for the extensive lesions determined by the elongation of the ureter that may tear at the level of the area of minimal resistance. The ureter's tear usually occurs in the area where the lumen narrows (ureteropelvic junction, pelvic strait, ureterovesical junction).

Although very rare, its incidence ranging from 0.2% to 1.5% (Blute et al., 1988; Assimos et al., 1994; Harmon et al., 1997; Oktay et al., 1997; Puppo et al., 1999), ureteral avulsion represents the most severe complication of ureteroscopy (Geavlete et al., 1999b).

The first cases were reported by Hart (1967) and Hodge (1973), both of them occurring after difficult manipulation of ureteral calculi with the basket catheter (Fig. 6.117).

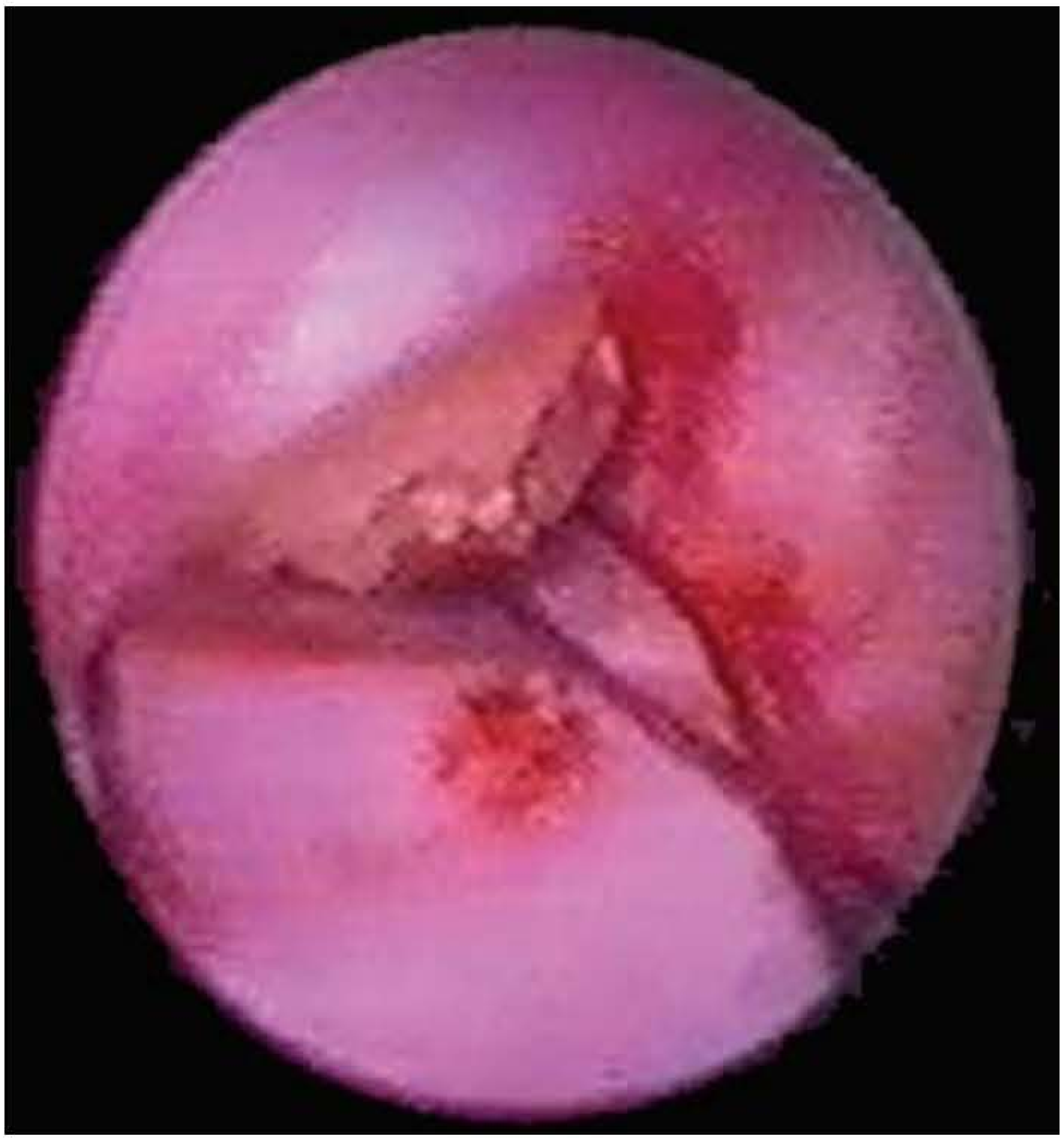

Figure 6.117 **Tractioning of the ureteral wall by exerting an excessive pressure on the basket catheter, in the attempt to extract a fixed stone.**

By assessing the articles published between 1984 and 1992, which included 5117 patients, Stoller and Wolf (1996) found 17 ureteral avulsions, the incidence of this complication being of 0.3%. On the other hand, Grasso (2001), assessing three series, including 1059 patients between 1992 and 1998, did not observe any cases of ureteral avulsion.

An important factor in the occurrence of this complication is represented by the failure to respect the basic rules of ureteroscopy. Thus, the following are involved: use of inadequate equipment, the lack of performing dilation of the ureteral orifice when this is necessary, inadequate use of the basket catheter for extracting ureteral calculi, and the difficulties of visualization during lithotripsy maneuvers (Chang and Marshall, 1987). The major risk factors are represented by the use of basket catheters with multiple spirals, especially in cases of calculi larger than 1 cm, and the distance over which the stone must be extracted up to the ureteral meatus (Abdelsayed et al., 1977). Due to these issues, the use of the basket catheter for extracting lithiasic fragments is limited in many centers.

The risk of ureteral avulsion is higher when using rigid ureteroscopes (Martin et al., 1998).

Another potential factor involved in the pathogenesis of ureteral avulsion is the presence of a pathological ureteral area, either as a result of a condition at this level, or due to previous endoscopic or open surgical interventions.

The diagnosis of ureteral avulsion can usually be established immediately after its occurrence during the endoscopic procedure by recognizing a tubular structure engaged after the ureteroscope during the extraction maneuvers (Fig. 6.118). The lesion can sometimes be identified by retrograde pyelography, performed if a ureteral lesion is suspected. In this situation, the complete leakage of the contrast media is observed, without opacification of the part of the ureter proximal to the lesion.

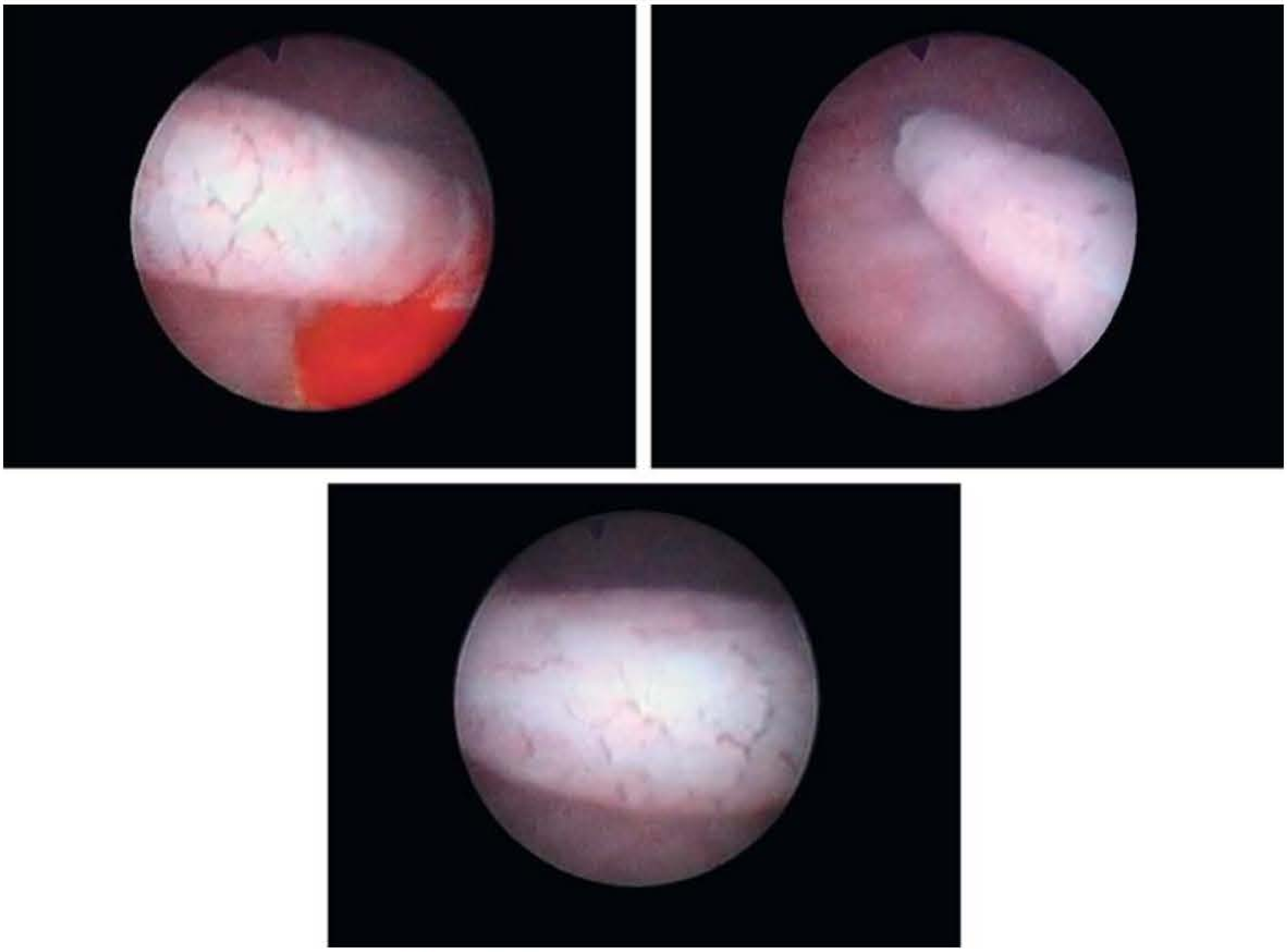

Figure 6.118 **Iatrogenic ureteral avulsion.**

However, the diagnosis may sometimes be revealed late through fever, lumbar pains, palpable lumbar tumoral mass, symptoms determined by the retroperitoneal urinoma, or the abscess secondary to the urine leakage (Martin et al., 1998). In these cases, the diagnosis must always be confirmed by ultrasonography, CT scan, intravenous urography, or retrograde pyelography.

The degree of tissular lesions, as well as the extent of the process at the level of the ureteral wall, is difficult to assess intraoperatively.

Open or laparoscopic surgical intervention represents the elective modality for solving ureteral stripping, the purpose of the intervention being to restore ureteral continuity. However, there are no clear guidelines regarding the optimal therapeutic alternatives for this complication. The patient's age, functionality of the kidney, the level of the lesion, and the length of the ureteral defect must be taken into account when choosing the therapeutic alternative. If the ureter's continuity can be restored through the safety guidewire, ureteral stenting for several months can be attempted, with secondary restoration of the ureteral wall. This alternative implies an important risk of ureteral stenoses.

If the lesion affects the distal ureter, ureteroneocystostomy can be performed. Sometimes, psoas hitch or Boari flap plasty procedures, or a combination of them, may be required to achieve reimplantation. Their application is limited only to ureteral lesions located inferior to the pelvic strait. Chang and Koch (1996) described a modified technique of the traditional procedure with vesical flap or of the procedure with spiral flap in two patients with lesions of the proximal ureter.

The lesions of the middle ureter can be treated by termino-terminal anastomosis on a ureteral stent. This alternative may be applied if the ureter has not been devitalized. In situations with complete avulsion of the ureter at the pyeloureteral junction, the first-line therapeutic alternative is represented by pyeloplasty.

In cases with important tissular losses, autotransplantation, especially in young patients, or interposition of an ileal loop can lead to favorable results (Shokeir, 1997; Martin et al., 1998). Ureteroplasty must be performed with enterovesical reimplantation with or without antireflux mechanism. Ureteroplasty with a segment of ileon may lead to metabolic disorders in the long term.

Another alternative for the healing of extensive lesions using interposition of the vermiform appendix was reported in three cases in which the classic therapeutic methods could not be used (Die Goyanes et al., 1983; Lloyd and Kennedy, 1989; Juma and Nickel, 1990).

Renal autotransplantation represents a viable alternative even in case of a short remnant ureter. The long-term results are superior compared to ureteroplasty with ileal loop.

Uretero-transureterostomy requires a ureteral segment long enough to cross the midline. This alternative raises the problem of the operative aggression on the contralateral urinary tract, and is indicated only as a last resort if the other therapeutic alternatives cannot be used.

In very rare cases, nephrectomy can represent the most adequate option in patients with a normal contralateral kidney, in whom the attempt to preserve the affected renal unit implies additional risks (Grasso, 2001).

The intraoperative detection of the complication requires immediate surgical intervention. If the lesion is diagnosed late or if the patient requires additional preparation or stabilization measures, percutaneous nephrostomy can be performed until the lesion is definitively resolved.

Ureteral avulsion can be prevented by using an adequate technique. The extraction of middle or proximal ureteral calculi with the basket catheter must be performed with strict precautionary measures. The intact extraction of calculi embedded in the ureteropelvic junction or of pyelic calculi is contraindicated, excepting cases in which they are very small.

Dilation of the intramural ureter is required in most cases in which the calculi are extracted intact. Moreover, it is contraindicated to extract, with the basket catheter, calculi that are larger than the narrowest area of the ureter that is to be crossed. This complication can be avoided by fragmenting the large calculi before extraction.

Because the ureter's caliber is difficult to estimate, it is recommended to use extracting catheters with separate fibers that allow for releasing the stone if difficulties regarding its extraction are encountered. If the stone cannot be extracted safely, it is recommended to perform lithotripsy into fragments than can be eliminated spontaneously or that can be easily extracted.

In conclusion, a determining role in preventing ureteral avulsion is played by the surgeon's experience, by avoiding extraction of the calculi with the basket catheter, by fragmenting before extraction, and by an adequate visualization during the lithotripsy maneuvers.

6.6.2.11. Partial Ureteral Avulsion

Partial ureteral avulsion is a less frequent complication which determines less severe sequelae. If a safety guidewire was not ascended during the procedure and if the lesion could not be surpassed with a guidewire, percutaneous nephrostomy and antegrade ureteral stenting are recommended (Stoller and Wolf, 1996).

6.6.3. Early Postoperative Complications

6.6.3.1. Infection/Sepsis

The introduction of pathogenic germs into the upper urinary tract during instrumentation represents an important cause of secondary urinary tract infections. Also, manipulation of potentially infected urinary calculi may lead to sepsis. The use of an increased irrigation pressure in the presence of urinary infection leads to bacteremia.

The incidence of fever in the immediate postoperative period is relativey high. This does not always reflect the presence of urinary infection or of bacteremia. Sometimes, it is determined by chemically induced sterile renal inflammation (Stoller and Wolf, 1996). Fever over 38°C represented the most frequent complication (6.4%) reported by Blute et al. (1988) in a series of 346 ureteroscopies. Similar results were obtained by Abdel-Razzak and Bagley (1992) in a group of 290 patients. Grasso (2001) and Harmon et al. (1997) reported an incidence of 1.2–1.3% for postoperative fever. Preoperative antibiotic therapy determines a decrease in the risk of fever and postoperative infections. Assessing a group of patients in whom postoperative antibiotic therapy was administered only in complicated cases, Jeromin and Sosnowski (1998) reported an incidence of 22% for fever, although urinary infection was detected in only 3.7% of cases. Francesca et al. (1995) noted the presence of urinary infection in 22.5% of patients in whom retrograde ureteroscopy was performed using large-caliber ureteroscopes, compared to 4% in patients in whom low-caliber semirigid ureteroscopes were used. The explanation for this difference is not clear. The incidence of sepsis after ureteroscopy is low. Schuster et al. (2001) observed an incidence of urinary infection of 1.2%, sepsis occurring in 0.3% of cases, while Stoller et al. (1992) found a 2% rate of septic episodes. There is no exact differentiation in the literature between infection and sepsis, and for this reason the reported data are very different. Although urinary infection or sepsis may occur even if the urine was sterile before the intervention, all measures for preoperative sterilization of the urine must be taken. Preoperative antibiotic therapy according to the uroculture is mandatory. However, administration of prophylactic antibiotic therapy in patients with negative preoperative uroculture represents a controversial subject.

Besides the preoperative sterilization of urine, urinary infections and bacteremia can be prevented by reducing the irrigation pressure, especially in case of infected lithiasis. The pressure must be maintained at a level sufficient enough for ensuring adequate visibility. Reduction of the pressure in the upper urinary tract may be obtained by using the ureteral access sheath (Rehman et al., 2001), an angiographic catheter, or by periodically draining the collecting system through the ureteroscope. Additionally, continuous or intermittent drainage of the bladder may contribute to maintaining a reduced pressure during ureteroscopy.

6.6.3.2. Ureteral Obstruction

The lesions of the ureteral mucosa generated by instrumentation of the upper urinary tract can determine obstruction due to local edema, clots, or ureteral spasm. Ureteral stenting at the end of the procedure determines a reduction in the rate of this complication. The incidence of renal colic and of lumbar pains after ureteroscopy reported in different studies was 4–9% (Abdel-Razzak and Bagley, 1992; Grasso, 2000). Harmon et al. (1997) remarked a rate of renal colics of 3.5%, in 2.6% of cases being necessary to reposition the ureteral stent. Obstruction is generally autolimited and can be treated by conservative measures, including administration of analgesics and anticholinergics.

If the pain persists, imagistic explorations are necessary for detecting the location of the obstacle and for clarifying the presence and degree of obstruction. Ureteral stenting may ensure remission of symptomatology.

6.6.3.3. Vesicoureteral Reflux

Vesicoureteral reflux may occur after ureteroscopy, even in cases in which ureteral dilation is not performed beforehand. Richter et al. (1999) demonstrated the presence of reflux 24 h after the procedure in 10% of the 40 patients who underwent ureteroscopy after dilation of the ureteral orifice to 13.5 F. Repeating the cystography after 2 weeks demonstrated the resolution of the reflux in all cases. Other investigators (Ford et al., 1984; Ono et al., 1989; Stoller et al., 1992; Roberts et al., 1998) remarked the presence of reflux in 5–10% of patients after 3–20 months from the procedure, most of them in cases in which dilation of the intramural ureter was performed (Fig. 6.119). The use of small-caliber semirigid or flexible ureteroscopes does not require dilation of the ureteral orifice, reducing the incidence of the reflux.

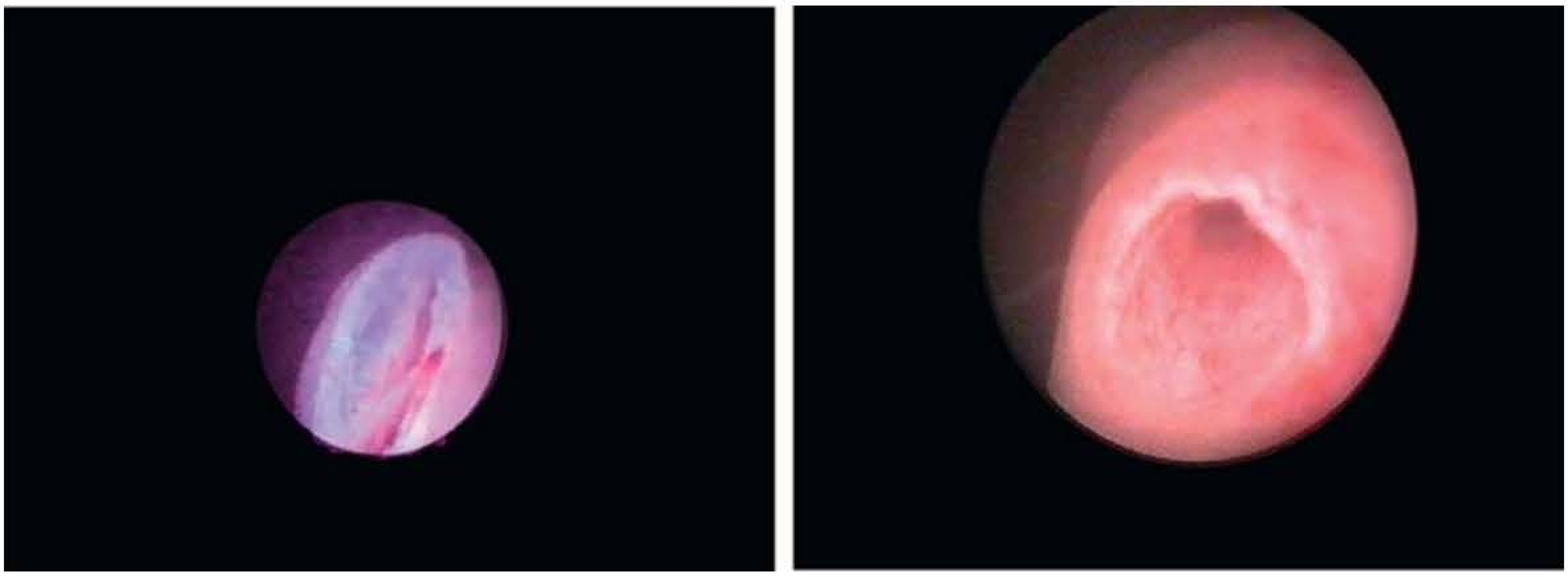

Figure 6.119 Aspect of the ureteral orifice after ureteroscopy.

6.6.3.4. Rare Complications

Ureterointestinal fistulas can be seen exceptionally in patients with a history of radiotherapy. Total necroses of the ureter have been described, attributed to partial perforations, followed by submucosal progression of the ureteroscope, leading to a devascularization of the longitudinal vascular plexuses of the ureter.

6.6.4. Late Postoperative Complications

Late complications are very rare due to the technical advances regarding the instruments and to the increase in the surgeons' experience.

6.6.4.1. Ureteral Stenoses

The incidence of postureteroscopic ureteral stenoses ranges between 0% and 4%. These may occur as a consequence of ureteral traumas produced during instrumentation or as a result of stone impaction, being determined by the leakage of the fluid into the periureteral tissue, mucosal lesions, ischemia of the wall, or even by the thermal lesions generated by endoluminal lithotripsy (Biester and Gillenwater, 1986; Chang and Marshall, 1987).

Ureteral perforation at the site of the stone's impaction was considered to be the main risk factor in the occurrence of stenoses. Although Stoller and coworkers reported a global stenoses rate of 3.5%, this increased to 5.9% in patients in whom ureteral perforation occurred. In a retrospective study conducted in a group of 21 patients with ureteral stones impacted for over 2 months, Roberts et al. (1998) reported a rate of complications of 24% occurring after a mean period of 7 months from the ureteroscopy.

The incidence of this complication decreased considerably with the miniaturization of ureteroscopes and the progress regarding instruments and operative techniques. The initial studies using 9.5–12.5 F ureteroscopes remarked postoperative stenosis rates of over 4% (Carter et al., 1986; Schultz et al., 1987; Blute et al., 1988; Daniels et al., 1988; Geavlete et al., 2000b). Recent assessments have shown secondary stenosis rates of under 1% in patients in whom low-caliber semirigid or flexible ureteroscopes were used (Abdel-Razzak and Bagley, 1992; Francesca et al., 1995; Harmon et al., 1997). Thus, Netto remarked a stenosis rate of 0.7% after 7.5 F rigid ureteroscopy, these cases occurring in patients who underwent postoperative ureteral stenting (Netto et al., 1997).

Some authors have assumed that the use of the ureteral access sheath may favor the occurrence of postoperative stenoses. Delvecchio remarked a single ureteral stenosis after 71 ureteroscopic procedures in which the ureteral access sheath was used (Delvecchio et al., 2003).

All types of intraureteral lithotripsy have the potential of generating thermal energy with subsequent injury of the mucosa, which may lead to the formation of strictures. Each of these methods determines a local increase of temperature, which, in the narrow lumen, may determine thermal injury. It seems that the highest increase of temperature is determined by electrohydraulic lithotripsy, and the use of this method is most frequently associated with ureteral injury.

Due to the coexistence of other factors such as previous irradiation, endoscopic manipulation increases the risk of necrosis or devascularization of the ureter, a process which leads to the formation of ureteral stenosis. Other possible causes for the formation of orifice (Fig. 6.120) or ureteral lumen strictures (Fig. 6.121) may also be represented by the dilation of the terminal ureter.

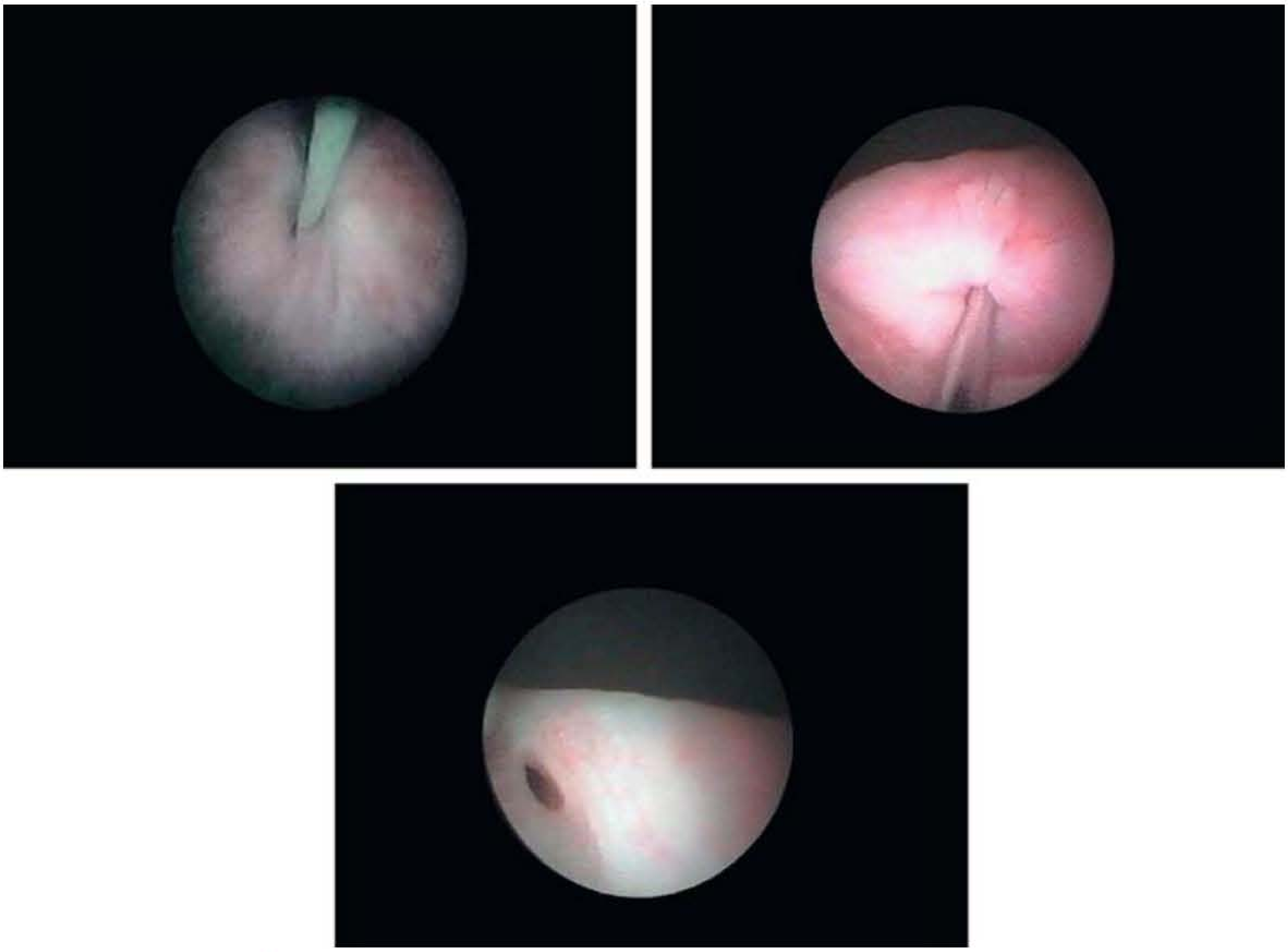

Figure 6.120 Ureteral orifice stenosis at 6 months after ureteroscopy.

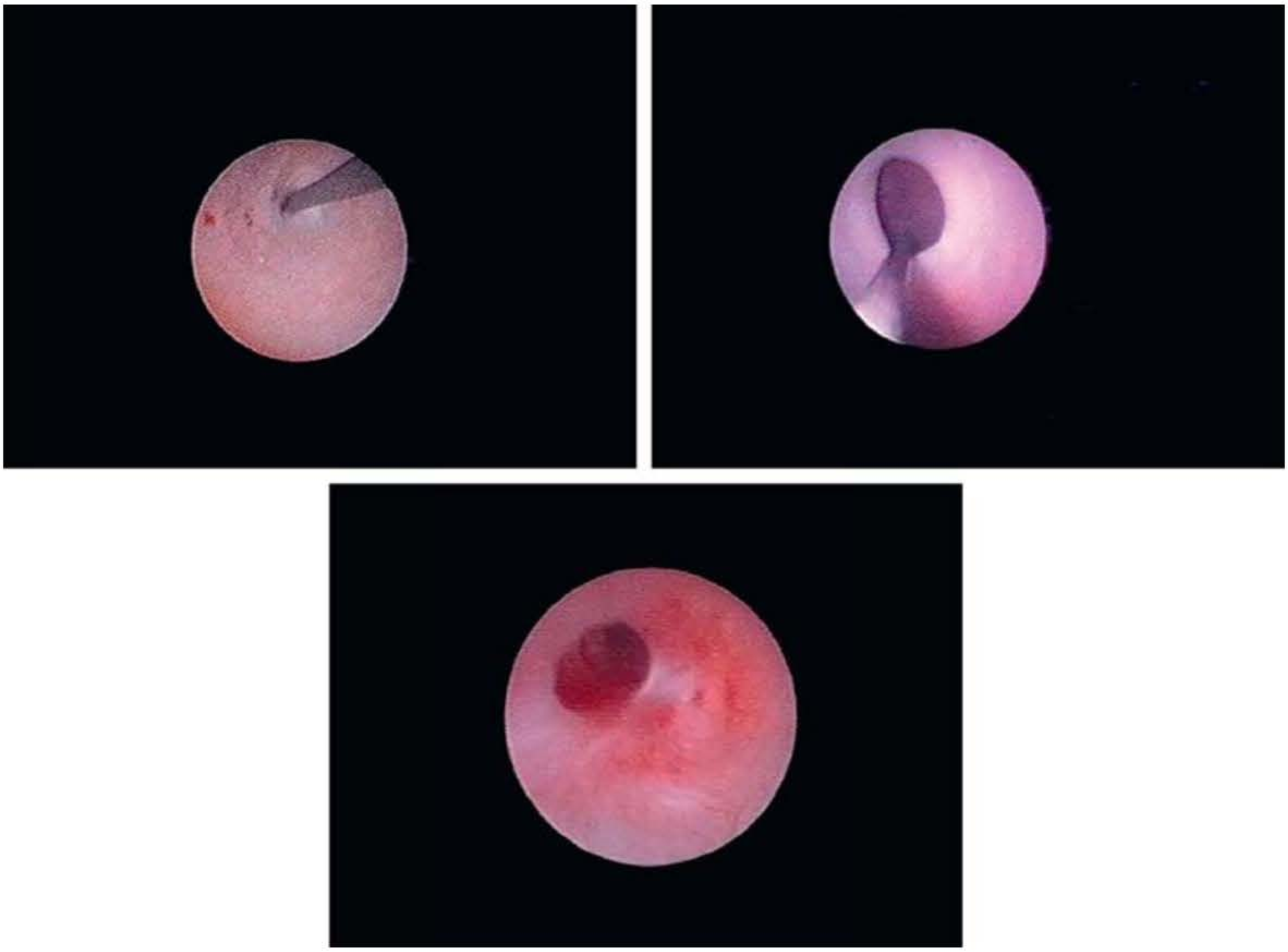

Figure 6.121 **Aspects of postureteroscopy ureteral stenosis.**

Due to the reduced rate of ureteral stenosis after using the new generations of ureteroscopes, some authors have raised the issue of the true necessity for imagistic investigations in following patients after ureteroscopy. Thus, Karod et al. (1999), reassessing a group of 183 patients who underwent ureteroscopy, remarked that none of the 110 asymptomatic patients assessed imagistically presented ureteral obstruction. This complication was detected in only 1 of the 21 patients with postoperative symptomatology. Based on these data, the authors state that postureteroscopic imagistic exploration may be avoided in asymptomatic patients, without intraoperative lesions. On the other hand, Weizer et al. (2002) remarked the presence of asymptomatic obstruction in 3.7% of cases, recommending routine imagistic exploration at 3 months after the procedure in order to avoid the potential complications of undiagnosed ureteral obstruction.

The careful manipulation of the ureteroscope, accessories, and calculi, with a reduction in ureteral traumas, can ensure prevention of secondary stenoses. Dilation of the narrowed areas of the ureter may reduce the rate of perforations and the risk of occurrence of late stenoses. Ureteral stenting and repeating the procedure after 7–10 days may facilitate ureteroscopic approach.

In case of ureteral perforations, placing a JJ stent for 2–3 weeks may reduce the risk of stenoses (Stoller et al., 1992). There are scarce data in the literature regarding the specific duration of stenting in these situations.

Postoperative ureteral stenosis requires the endoscopic assessment of the localization and extent of the affected area. The first-line treatment of these stenoses is represented by endoureterotomy because these strictures are generally nonischemic and short (Smith, 1988). Balloon dilation followed by placing a ureteral stent represents another viable alternative. Long, ischemic strictures, or those in which endoscopic treatment has failed, may benefit from open or laparoscopic surgical treatment with ureteroneocystostomy, psoas-hitch, termino-terminal ureteroraphy, ureteral plasty with ileon, or autotransplantation (Morales et al., 1959).

6.6.4.2. Persistent Vesicoureteral Reflux

Persistent ureteral reflux (Fig. 6.122) has a very low incidence, being favored by ureteral dilation, incision of the ureteral meatus, or lesions of the intramural trajectory.

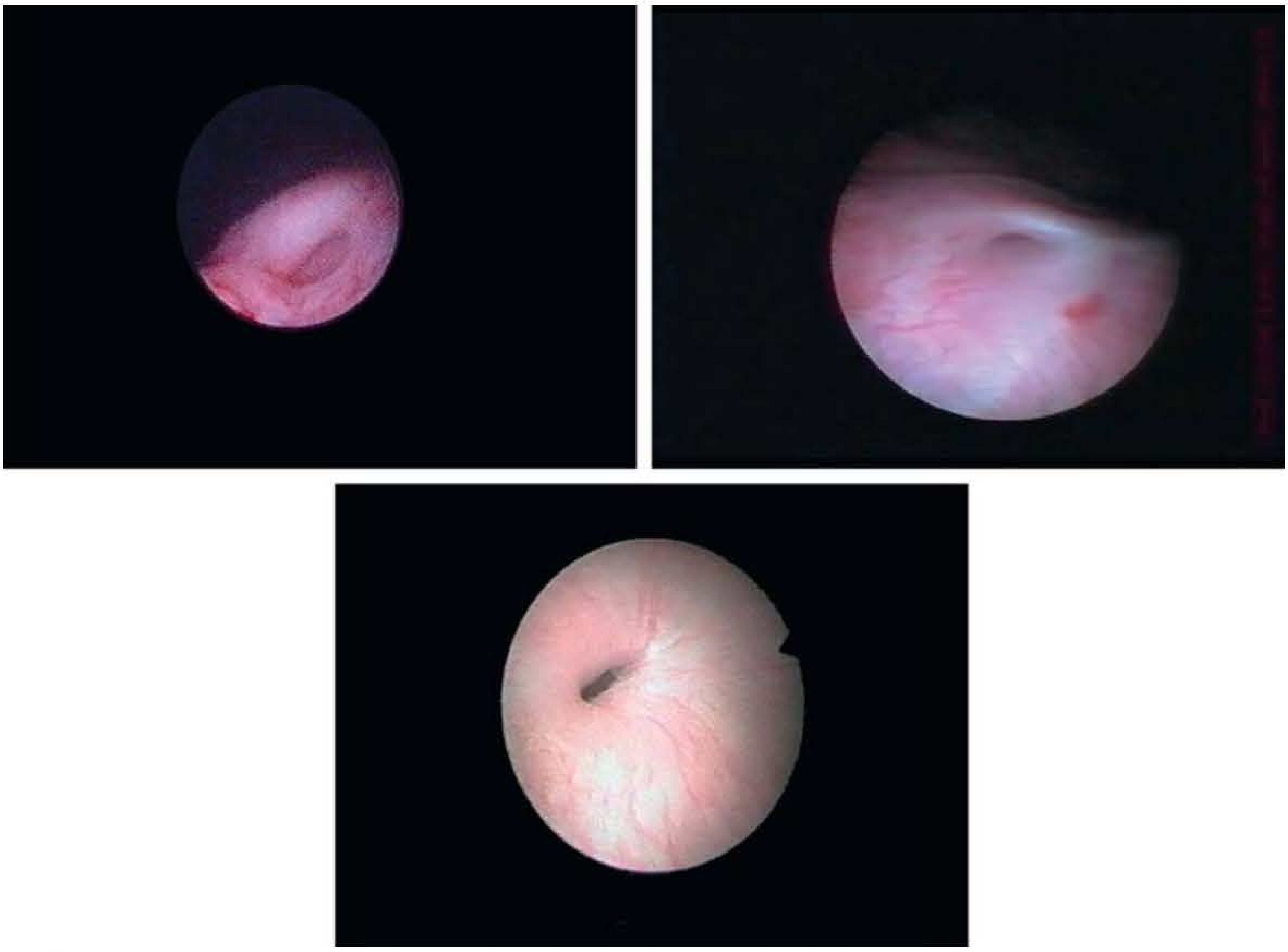

Figure 6.122 **Aspects of ureteral orifices in patients with persistent postureteroscopy vesicoureteral reflux.**

Postoperative vesicoureteral reflux rarely requires surgical treatment. Sterile, low-grade reflux occurring in adults has insignificant consequences in most cases. For this reason, routine radiological assessment of the reflux after ureteroscopy is not necessary (Stoller and Wolf, 1996).

Persistent vesico-renal reflux may benefit from endoscopic treatment by submucosal injection of Teflon, bovine collagen (Figs 6.123 and 6.124), autologous fluid fat, or from classic surgical treatment by creating different antireflux mechanisms (Geavlete et al., 1998).

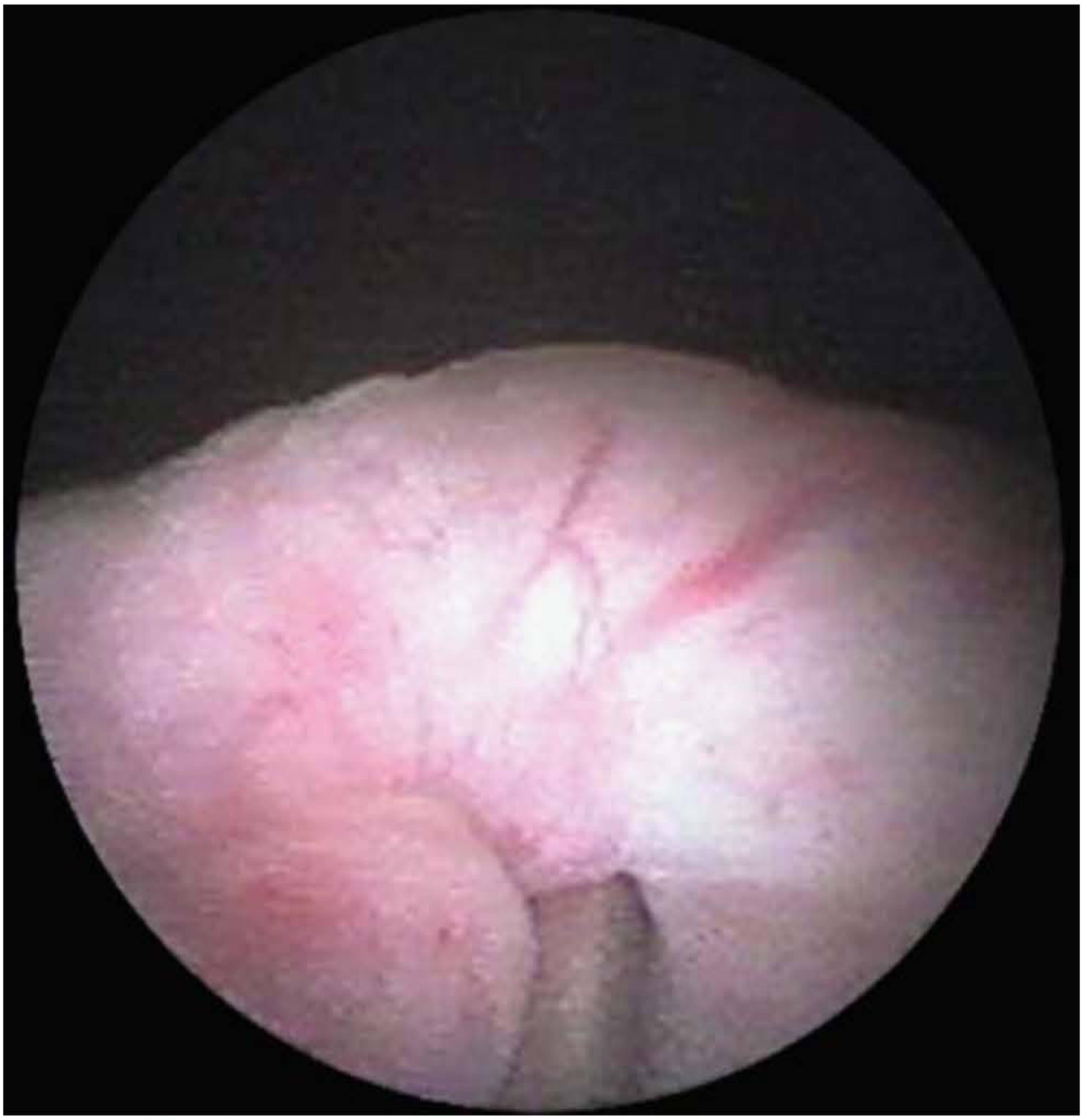

Figure 6.123 Collagen injection in a patient with vesicoureteral reflux.

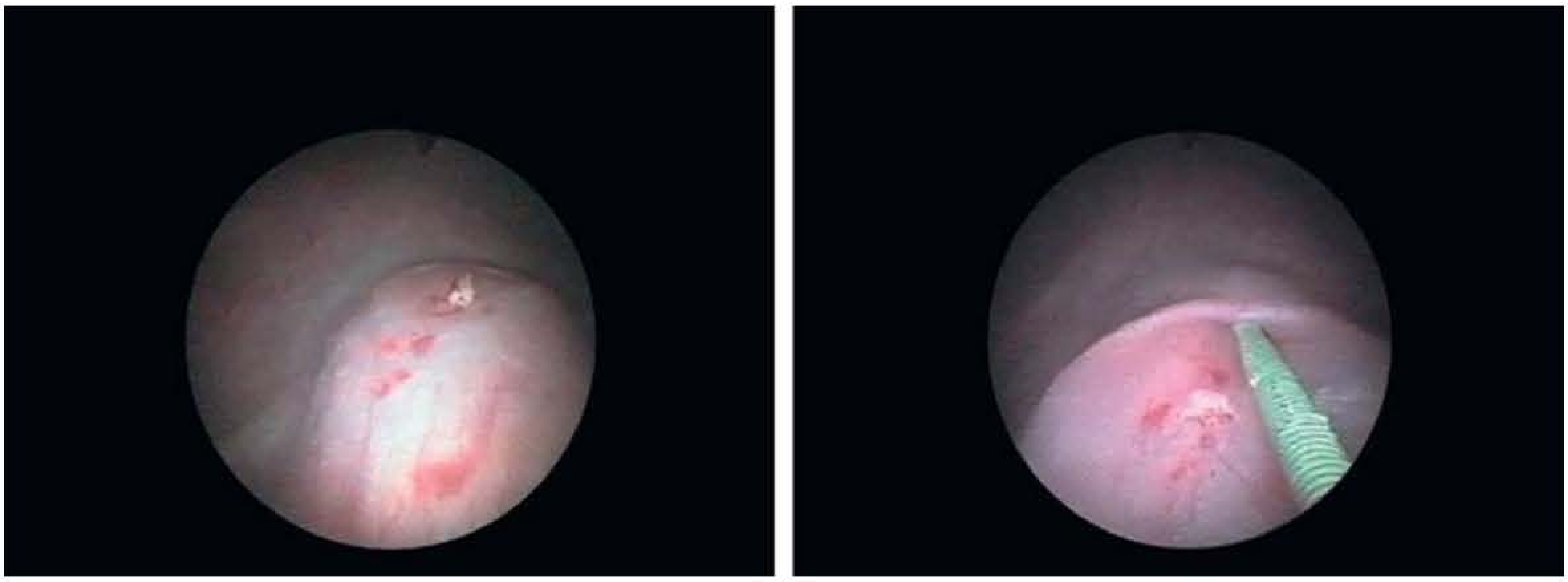

Figure 6.124 Postoperative aspects after collagen injection.

6.6.5. Measures for Preventing Complications

Most ureteroscopic complications can be prevented by applying proper techniques. A careful patient selection and adequate planning of the intervention are of major importance.

An obvious correlation was noted between the rate of complications and the equipment used, as well the surgeons' experience.

The choice of adequate equipment and accessory instruments is the decisive element in reducing complications. Any ureteroscopic procedure must be performed under fluoroscopic control and with a safety guidewire for maintaining ureteral access. Using proper techniques and maintaining an adequate visibility during the entire intervention are major elements for reducing the complications rate. Incomplete fragmentation of calculi and reduction of visibility due to bleeding require interrupting the intervention and ureteral stenting, resuming the procedure in a second step. This attitude is preferred to persistence with the increase in the risk of ureteral lesions.

An adequate surgical technique is required in order to prevent traumatic lesions of the ureter, respecting each operative step (Flam et al., 1988).

In general, iatrogenic lesions of the ureter occur in the first part of the learning curve, the risk of ureteral avulsion being higher in case of inexperienced surgeons.

On the other hand, with the increase in experience, the surgeon will take on more difficult cases, so that the possibility of occurrence of ureteral lesions, including ureteral stripping, remains high. The advances regarding endoscopic equipment, with the development of low-caliber instruments, have reduced the risk of these complications.

6.7. Ureteroscopy in the treatment of particular situations of lithiasis

6.7.1. Lithiasic Obstructive Anuria

Lithiasic obstructive anuria (Fig. 6.125) represents a therapeutic emergency that requires rapid disobstruction of the urinary tract. The therapeutic measures must be adapted to the patient's clinical status (Sinescu, 1998).

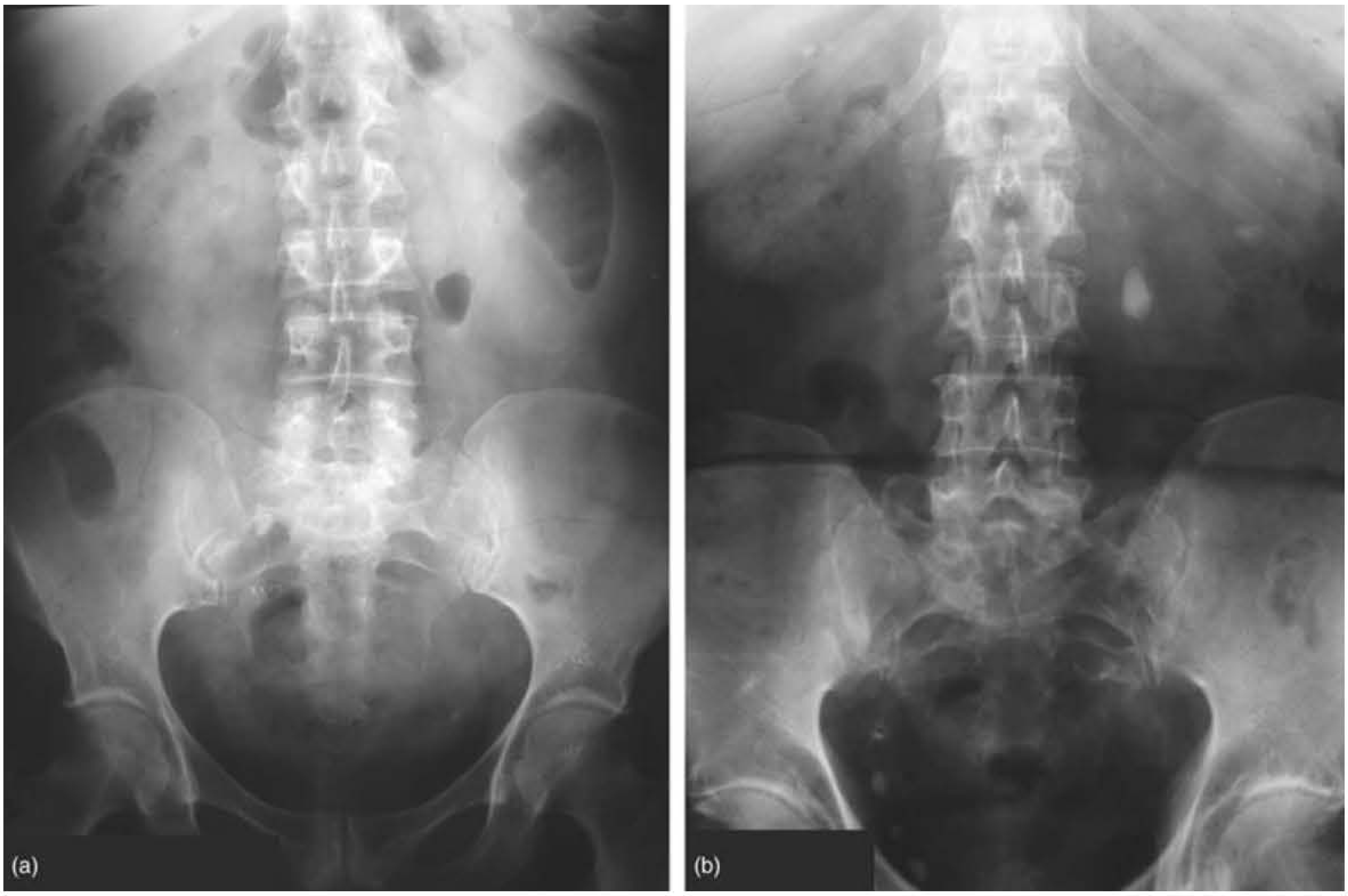

Figure 6.125

Obstructive anuria through bilateral ureteral lithiasis.

Left pelvic and right iliac (a), respectively left lumbar and right pelvic (b).

In the clinical tolerance phase, it is possible to resolve not only the anuria, but also the lithiasic cause (Figs 6.126 and 6.127; Geavlete et al., 1999c, 2000a). In this situation, the choice of the therapeutic alternative is dictated by the other factors that contribute to establishing the therapeutic protocol.

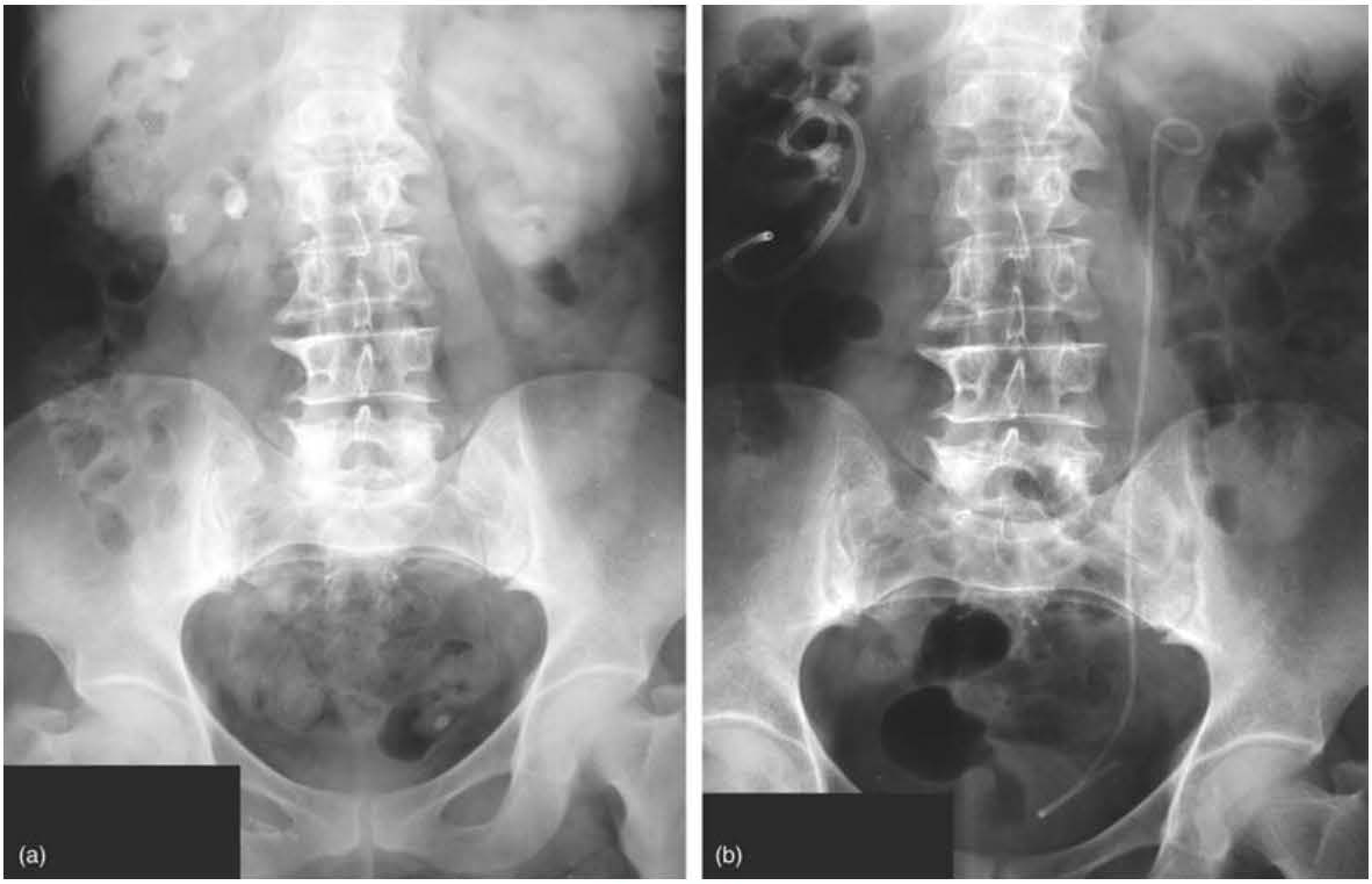

Figure 6.126

Lithiasis embedded in the right ureteropelvic junction and left pelvic ureteral lithiasis (a) for which right percutaneous nephrolithotomy and left ureteroscopy were performed during the same intervention (b).

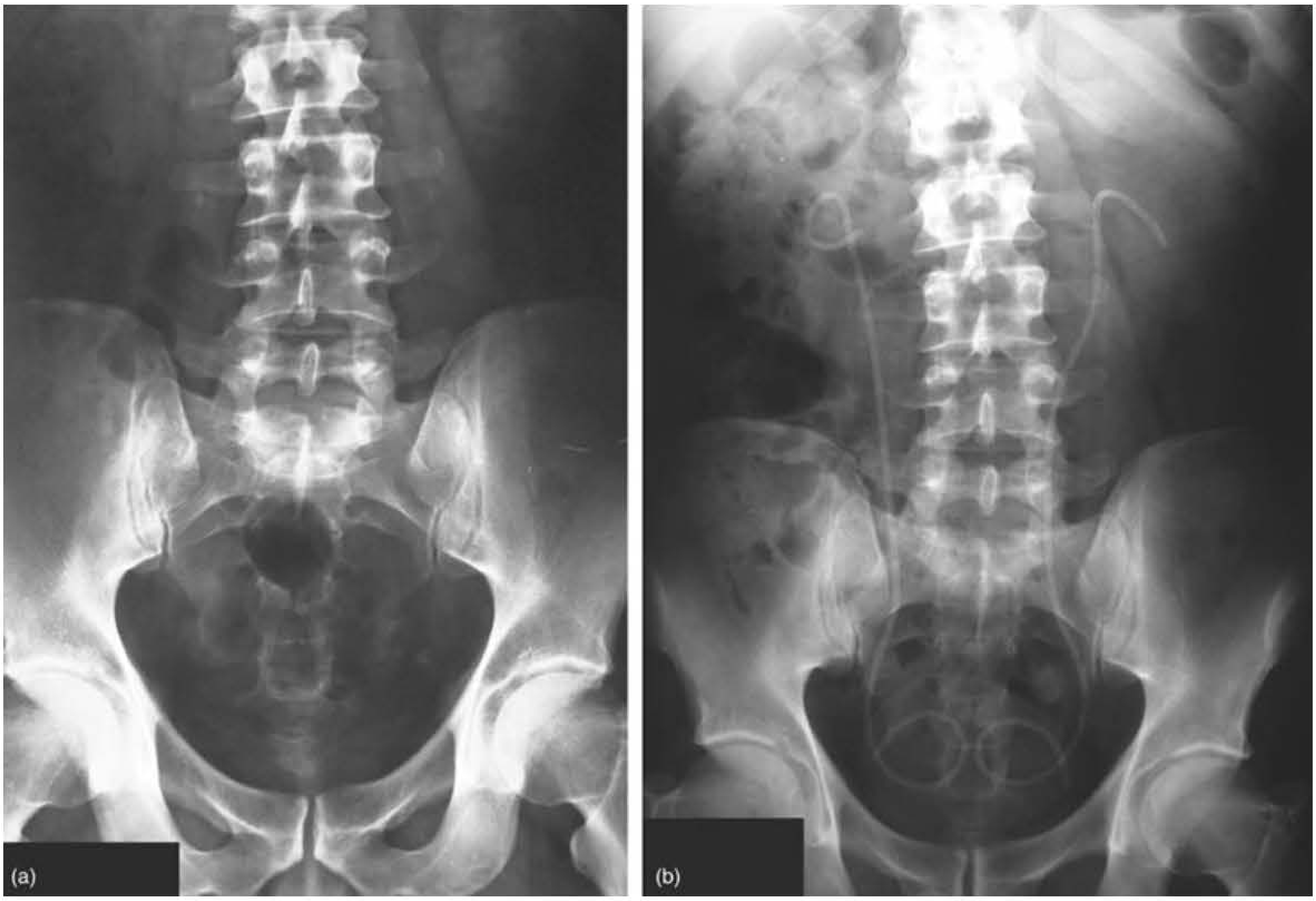

Figure 6.127

Right lumbar ureteral and left pelvic ureteral lithiasis (a) treated by bilateral

ureteroscopy followed by placement of JJ catheters (b).

In patients in the uremic phase, the patient's general status and the risks implied by a more ample intervention require achieving, in a first step, the disobstruction of the urinary tract by percutaneous nephrostomy or ureteral stenting. After the patient's general status has been restored and the renal function tests return to normal, treatment of the ureteral lithiasis can be performed according to the classic therapeutic protocol.

6.7.2. Steinstrasse Syndrome

The steinstrasse syndrome (Fig. 6.128) represents the obstruction of the ureter by accumulation of lithiasic fragments resulting after extracorporeal lithotripsy. This complication has an incidence ranging from 2% to 10%, correlated with the stone's dimensions (Coptcoat, 1987; Weinerth et al., 1989; Sulaiman et al., 1999).

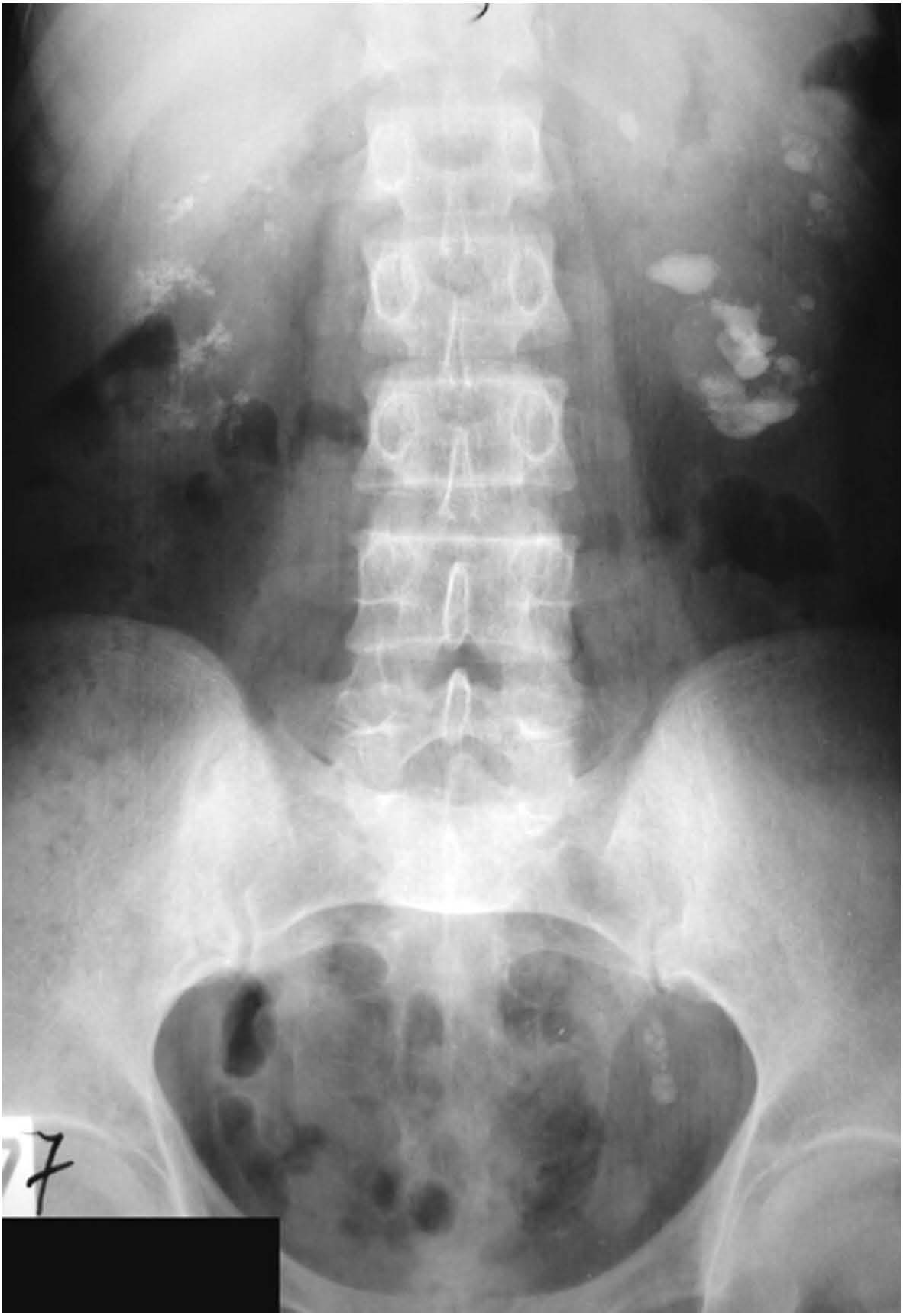

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Figure 6.128

Left steinstrasse syndrome (simple renovesical radiography).

Its incidence has decreased with the extensive use of percutaneous nephrolithotomy for large calculi (Coptcoat, 1987). Over 70% of steinstrasse syndromes occur in the distal ureter.

Placing a ureteral stent before extracorporeal lithotripsy significantly reduces, but does not eliminate, the risk of steinstrasse syndrome. However, the benefits of ureteral stenting are limited in patients with large calculi or with a single kidney (Coptcoat, 1987; Libby et al., 1988; Sulaiman et al., 1999).

The preprocedural placing of a ureteral stent proved to be useful especially in cases of calculi larger than 20 mm. The rate of occurrence of the steinstrasse syndrome in these patients was 15%, compared to 38% in those without ureteral stenting (Sulaiman et al., 1999).

The therapeutic attitude in the steinstrasse syndrome depends on the clinical particularities of each case. The steinstrasse syndrome is asymptomatic in 60–80% of cases, being detected due to the late eliminaton of the lithiasic fragments (Fedullo et al., 1988; Preminger et al., 1989; Kim et al., 1991). Most of these cases resolve spontaneously. Kirkali et al. (1993) noted that 82% of patients with steinstrasse syndrome spontaneously eliminated the lithiasic fragments. However, in patients with bilateral obstruction, obstruction on a single kidney, violent symptomatology, or associated urinary infection, an interventional treatment must be applied by ureteral stenting, percutaneous nephrostomy, or retrograde ureteroscopic approach. The large fragments with low chances of spontaneous elimination, as well as the failure of conservative treatment, represent additional indications for active intervention (Coptcoat, 1987; Weinerth et al., 1989).

When interventional treatment is required, a minimally invasive approach represents the first option, with a high success rate. Coptcoat et al. (1988) remarked that percutaneous nephrostomy allows for the elimination of fragments in 75% of cases. Detler recommended percutaneous nephrostomy in patients with violent symptomatology or sepsis, endoscopic interventions being reserved for patients without fever, with large residual fragments after at least 4 weeks of waiting. On the other hand, Weinerth et al. (1989) noted the fact that an important percentage of patients require endoscopic extraction of the fragments after percutaneous nephrostomy. The failure of conservative treatment after 3–4 weeks requires interventional treatment (Coptcoat et al., 1988).

Retrograde ureteroscopy represents a frequently used therapeutic alternative (Fig. 6.129).

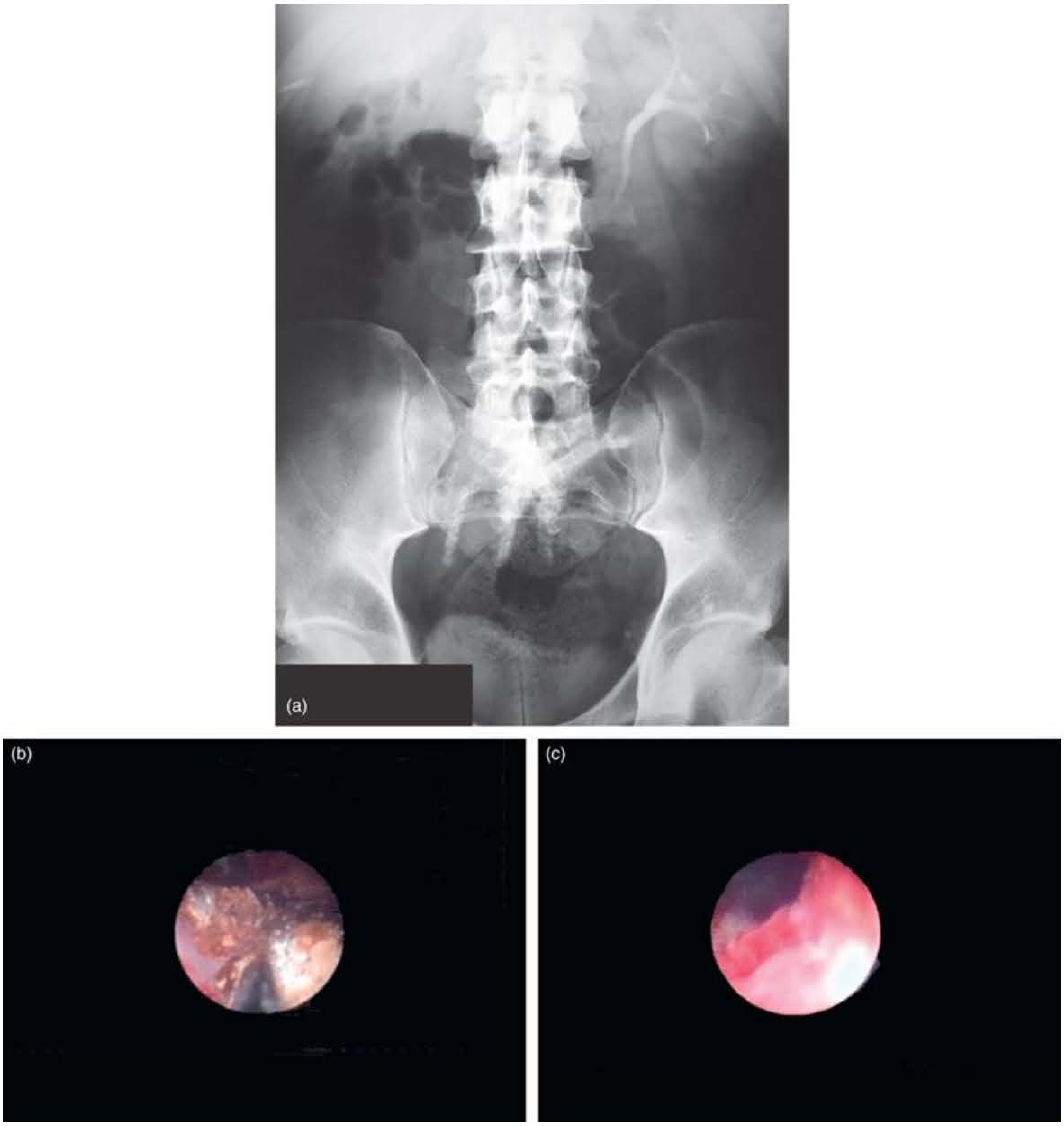

Figure 6.129

Retrograde ureteroscopic treatment of a right steinstrasse syndrome (a) secondary to SWL for a pyelic stone: ballistic lithotripsy of lithiasic fragments (b), stone-free aspect of the ureter at the end of the intervention (c).

Ureteroscopic extraction or lithotripsy of the fragments leads to a success rate of almost 100% (Coptcoat et al., 1988; Weinerth et al., 1989).

The results of treatment by retrograde ureteroscopy after initial decompression by percutaneous nephrostomy produced high success rates (Coptcoat et al., 1988). However, ureteroscopic intervention without preceding decompression may be difficult.

Sulaiman et al. (1999) reported a success rate of 96% for ureteroscopic treatment by laser lithotripsy and extraction with a basket catheter.

Ureteroscopic approach implies a high risk of intraoperative complications. Al-Awadi et al. (1999) recorded three cases of ureteral perforations that required open surgical intervention out of the nine cases treated endoscopically.

The incision of the ureteral orifice in order to facilitate the elimination of calculi was reported by Sigman (1988), but this method is rarely used as a single therapeutic modality.

Extracorporeal lithotripsy was used with a high success rate and with a low morbidity in the treatment of steinstrasse syndrome. Kim et al. (1991) remarked an incidence of 6% of the steinstrasse syndrome. Spontaneous elimination of the fragments occurred in 64% of cases, while 90% of cases refractory to conservative treatment were resolved by extracorporeal lithotripsy. Also, the authors reported an increased incidence of spontaneous passage for steinstrasse in the distal ureter compared to the proximal ureter (82% vs. 33%).

Percutaneous approach represents a therapeutic option for steinstrasse syndrome in the proximal ureter. Open surgical intervention has been described by many authors as an alternative in the case of failure of the other methods of treatment (Al-Awadi et al., 1999; Kim et al., 1991).

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7.1. Generalities

Caliceal (or pyelocaliceal) diverticula are intrarenal cavities (Fig. 7.1) lined by urothelium (Fig. 7.2), without secretion, that are passively filled with urine from the intrarenal tracts.

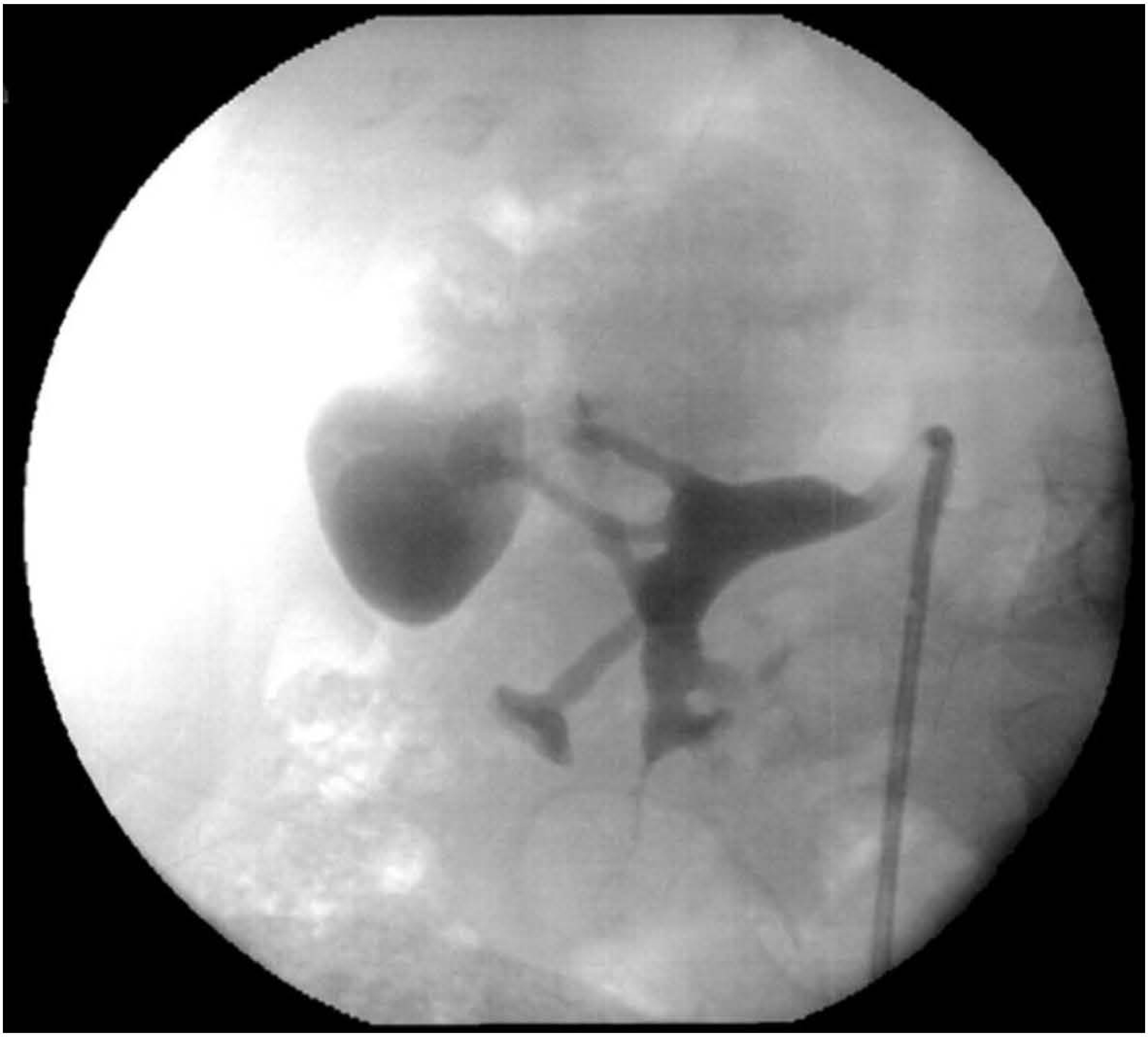


Figure 7.1 **Voluminous middle caliceal diverticulum (retrograde pyelogram).**

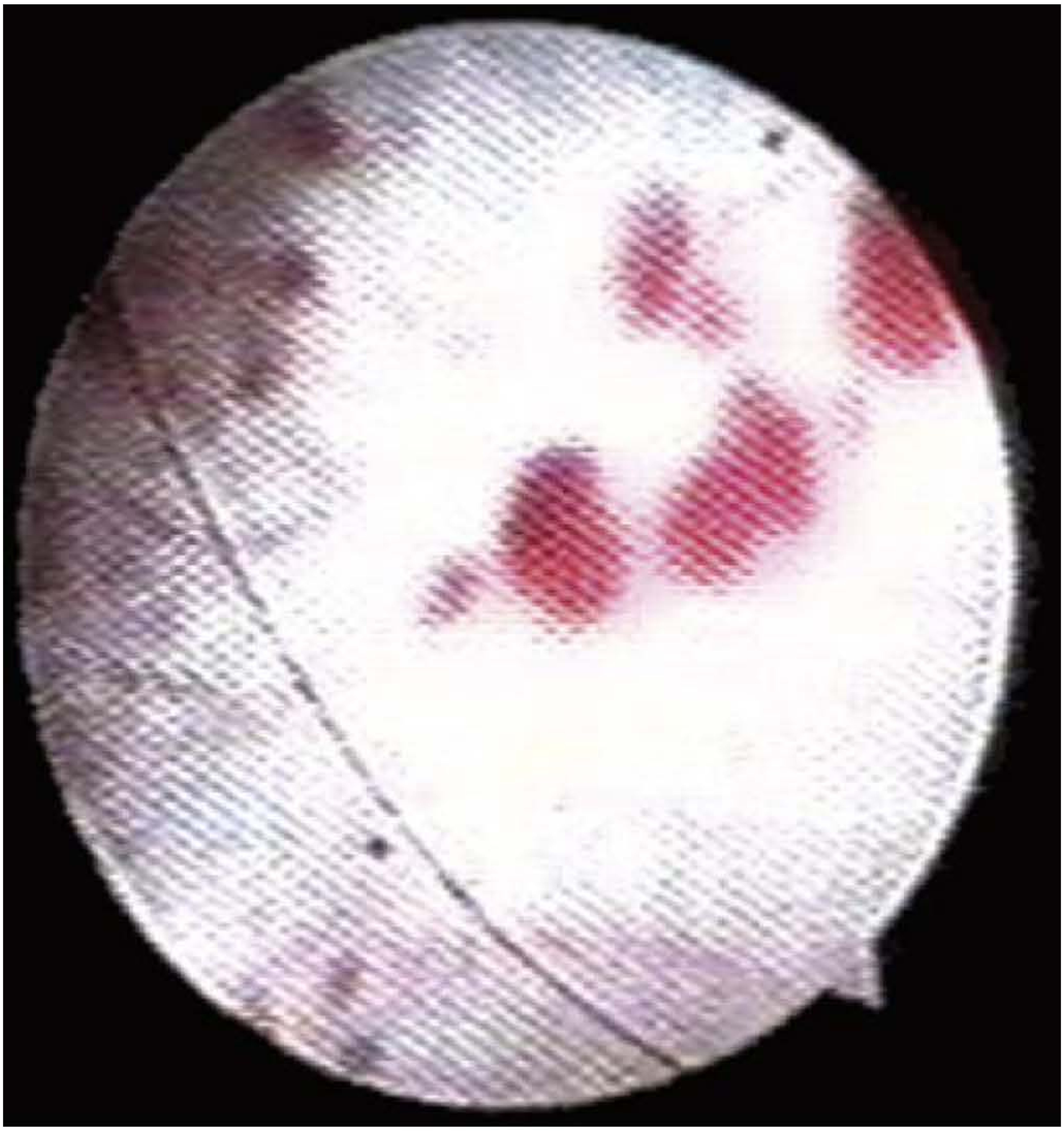


Figure 7.2 **Diverticular cavity lined with urothelium, without caliceal papilla (flexible ureteroscopic aspect).**

The diverticular cavity opens through the diverticulum's neck into a calyx (most frequently) (Fig. 7.3), into a caliceal infundibulum (Fig. 7.4), or even into the renal pelvis.

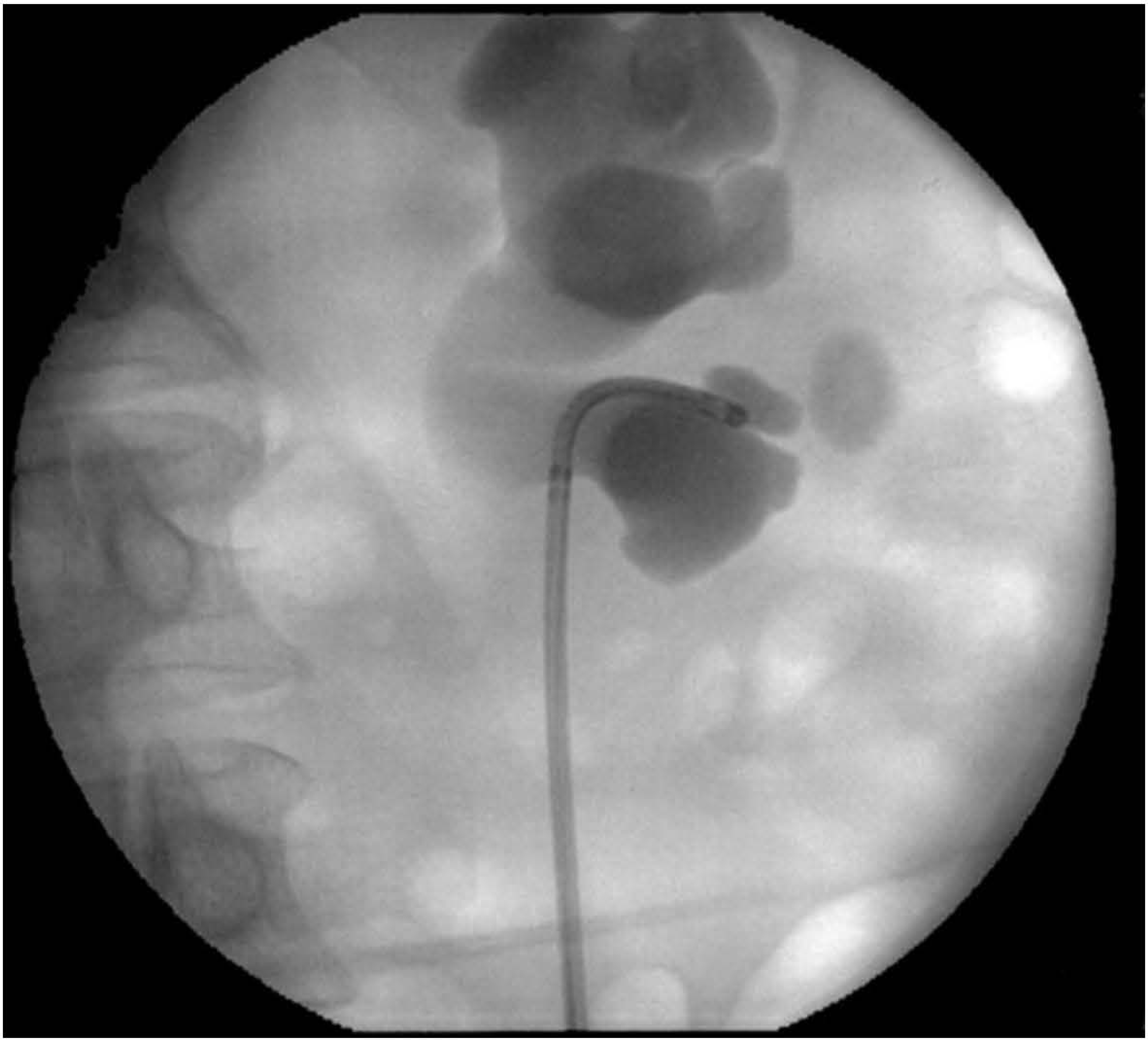


Figure 7.3 Diverticulum with the neck opening into the lower calyx (intraoperative fluoroscopy).

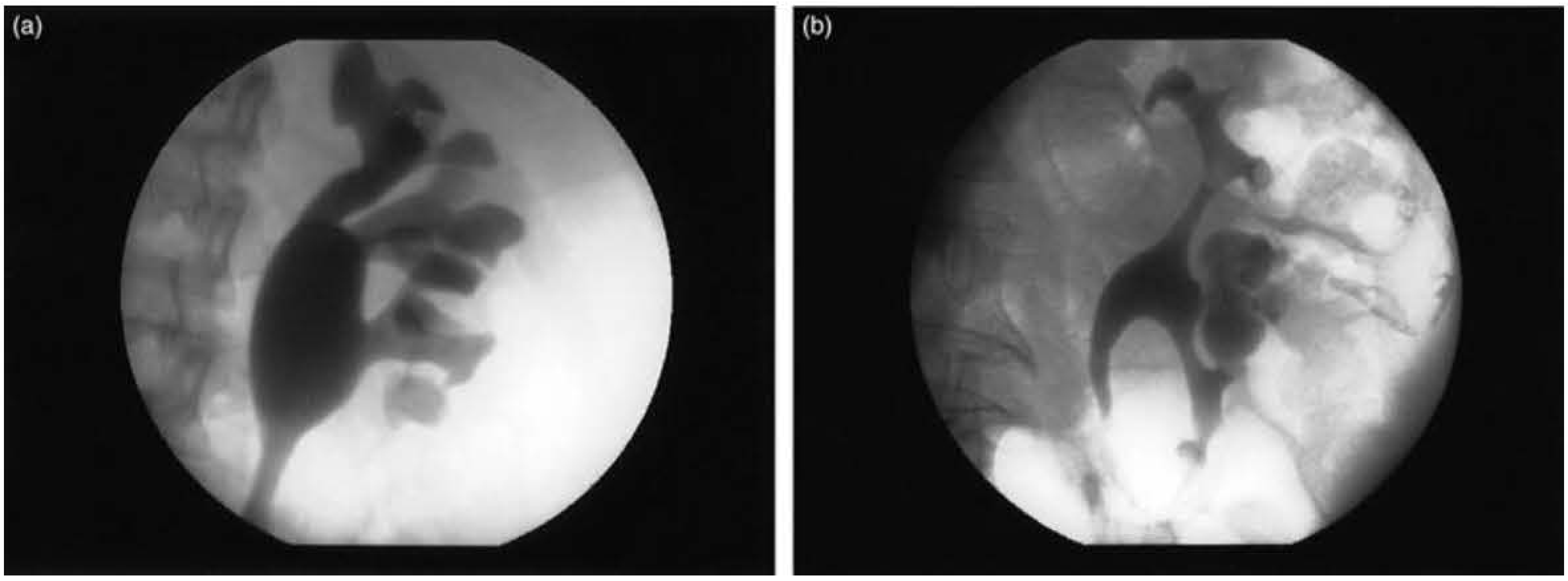


Figure 7.4 Diverticulum with the neck opening into the lower caliceal infundibulum (a) and two "hourglass" diverticula in the middle caliceal infundibulum (b).

The incidence of this malformation is relatively low, being discovered in 2.1–6 out of 1000 intravenous urographies in the adult population (Timmons et al., 1975; Landry et al., 2002). The analysis of groups of patients with caliceal diverticula published in the literature suggests a higher frequency in the upper caliceal group (Table 7.1).

Table 7.1

Distribution of Diverticula in the Caliceal Groups

Author	Upper calyx	Middle calyx	Lower calyx
Landry et al. (2002)	12	12	7
Auge et al. (2002)	28	7	7
Kim et al. (2005)	12	4	6
Total	52	23	20

There were no significant differences regarding the incidence according to gender or side. There are numerous theories regarding the etiology of caliceal diverticula. The most likely one seems to be the theory that supports a congenital origin for diverticula (Timmons et al., 1975; Apicella et al., 1975; Wulfhsohn, 1980). According to this theory, pyelocaliceal diverticula originate in the grade 3–4 ureteral buds, incompletely resorbed during weeks 5–8 of intrauterine life. The absence of renal papillae opening into the diverticular cavity is due to this mechanism of incomplete resorption.

Other authors have tried to establish correlations between the origin of renal cysts and that of caliceal diverticula. Thus, the progression of diverticula to simple renal cysts through the obliteration of the lumen and their separation from the intrarenal tracts has been suggested (Nicholas, 1975; Castejón Casado et al., 1984; Mosli et al., 1986). In turn, Reiss (1967) enunciated an inversed theory of caliceal diverticula genesis through the rupture of a simple cyst or of a renal abscess in the collecting system. However, the histological differences between renal cysts (lined with cuboid epithelium) and caliceal diverticula (containing urothelium inside the cavities) show that these theories, though possible, are applicable only to some isolated cases.

Amar (1975) suggested a mechanical-inflammatory mechanism for the production of diverticula. Thus, by studying a group of children with vesicoureteral reflux and urinary infection, he reported a higher incidence of caliceal diverticula than in the general population. However, Timmons et al. (1975) disputed this theory, showing radiographic signs of pyelonephritis in only 17% of cases in a group of 72 consecutive patients with pyelocaliceal diverticula.

Several classifications have been proposed for pyelocaliceal diverticula, based on anatomical, radiological, or radio-endoscopic criteria.

Thus, Wulfhsohn (1980) classifies diverticula according to the insertion of the diverticular neck into:

- Type I – cavities communicating with a minor calyx or with its infundibulum
- Type II – cavities communicating with a major calyx or with the renal pelvis

According to the length and the opening of the neck, Dretler (1992) classifies diverticula into four types:

- Type 1– wide and short neck
- Type 2 – narrow and short neck
- Type 3 – narrow and long neck
- Type 4 – obliterated neck

Using anatomical, radiological, and endoscopic criteria, Hulbert et al. (1988) classifies any intrarenal tract stenosis (including also the diverticular necks in this group) as:

- Type I – neck/lumen that allows the passage of a metallic guidewire
- Type II – radiologically visible neck/lumen, but which cannot be passed by the metallic guidewire
- Type III – completely obliterated neck/lumen

Diverticula can be single or multiple, with or without intradiverticular stones (Fig. 7.5).

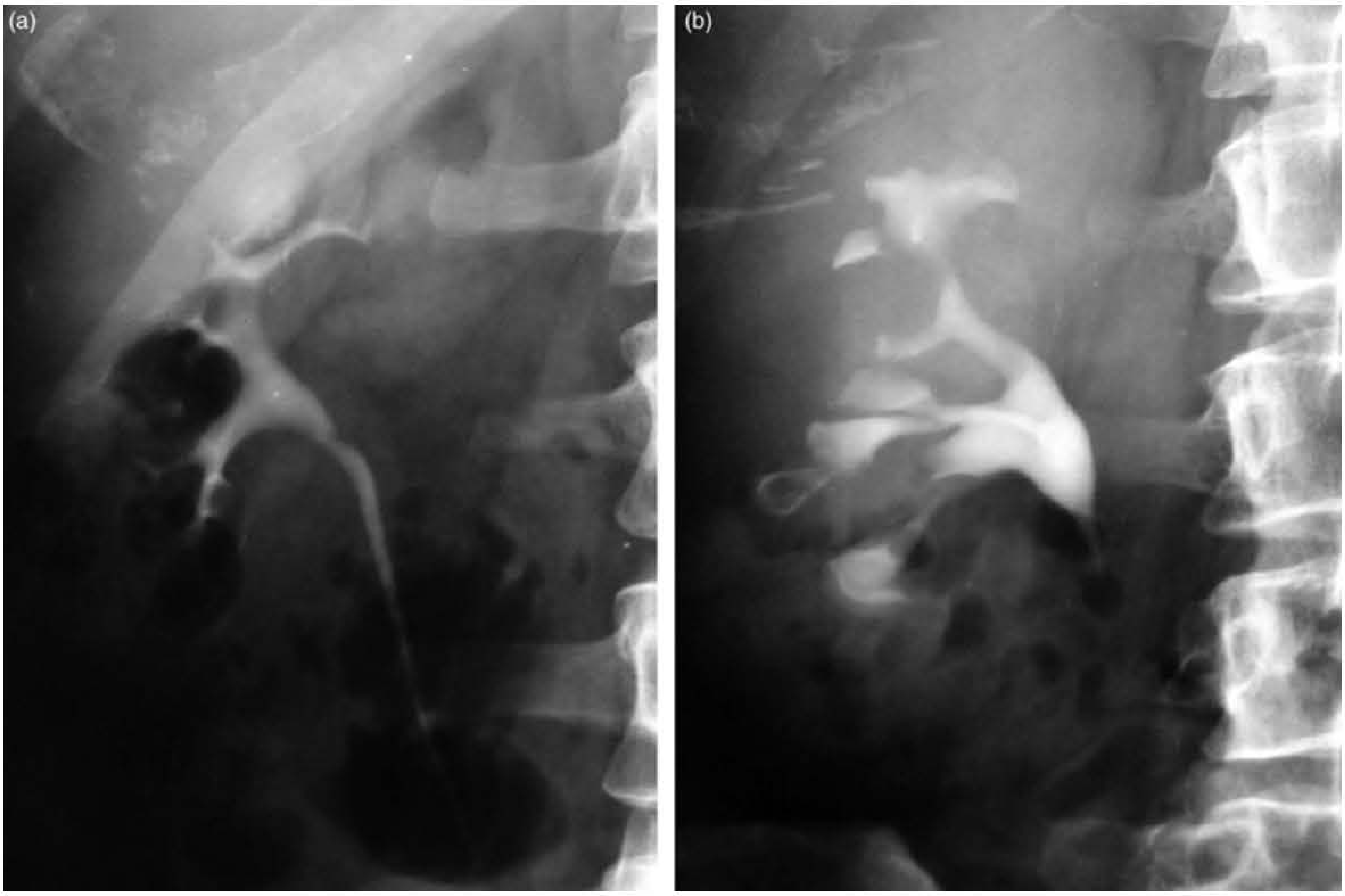


Figure 7.5 Radiological aspects of intradiverticular stones in the upper calyx (a) and middle calyx (b) (intravenous urography).

A particular form of diverticular lithiasis is the soft one, of the “milk of calcium” type (Fig. 7.6) (Garrett and Holland, 1973; Widder and Newhouse, 1982; Diaine et al., 1991; Multescu et al., 2006). “Milk of calcium” stones represent approximately 0.6% of cases of urinary lithiasis (Virgili et al., 1996).

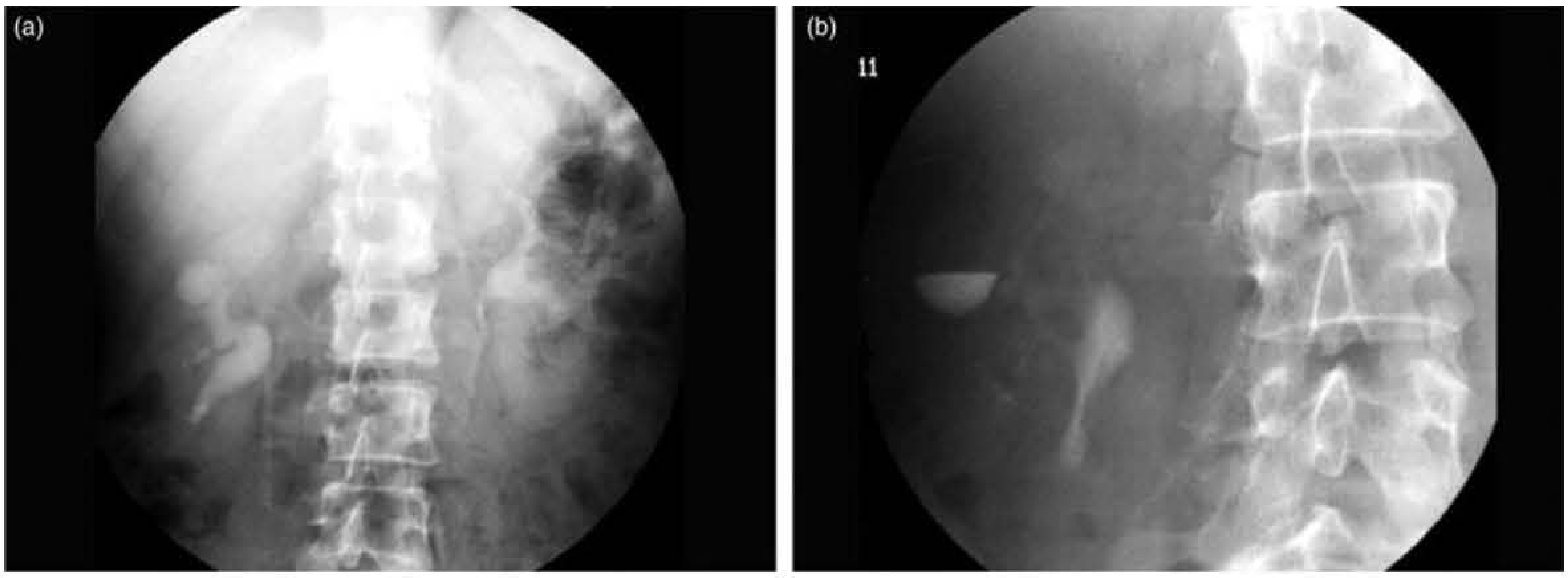


Figure 7.6 Right upper calyx diverticulum (a), urography in orthostatism showing “milk of calcium”-type intradiverticular lithiasis (b).

Isolated cases of patients with myxoid fibroepithelial polyps (Ritchey et al., 1985) or intradiverticular transitional tumors have been reported (Adachi et al., 1989).

7.2. Indications of retrograde ureterorenoscopic approach for caliceal diverticula

Most caliceal diverticula are asymptomatic (Rapp and Gerber, 2004) and are usually discovered incidentally. Some patients with caliceal diverticula may present lumbar pain, hematuria, or pyuria. In the series of patients reported in the literature, the incidence of intradiverticular lithiasis varies between 9.5% and 50% (Middleton and Pfister, 1974; -Timmons et al., 1975; Yow and Bunts, 1995; Matlaga et al., 2006). Less than half of the patients with symptomatic caliceal diverticula require surgical treatment. The indications for surgical treatment are represented by chronic pain, recurrent urinary tract infections, macroscopic hematuria, and progressive destruction of the renal parenchyma, regardless of the existence or not of intradiverticular stones (Geavlete et al., 2004a, b). The presence of stones is not an indication for surgical intervention in the absence of the other signs and symptoms mentioned previously.

Classically, open surgical interventions were the only therapeutic option. These were represented by partial or total nephrectomy, diverticulum resection, autologous fat filling, and neck suture, respectively partial resection of the diverticulum and parenchymal suturing after neck dilation. The development of endourological techniques currently offers a wide range of additional alternatives: retrograde ureterorenoscopic approach (Batter and Dretler, 1997; Baldwin et al., 1998), direct and indirect percutaneous approach (Shalhav et al., 1998; Kontak et al., 2007; Geavlete et al., 2007), laparoscopic approach (Ruckle and Segura, 1994; Wong and Zimmerman, 2005), or even SWL (Hendrikx et al., 1992).

Choosing the type of intervention depends on the position of the diverticulum, its dimensions, the presence and the dimensions of lithiasis, the available equipment, patient preference, and the surgeon's experience.

Although direct percutaneous approach is a widely used minimally invasive method, retrograde ureterorenoscopic treatment may be a viable alternative for selected cases. The improvements to the flexible ureteroscopes, the use of the Ho:YAG laser, and the technological progress in the field of accessory instruments have led to this type of approach being used more and more frequently. The development of diverticula, especially in the upper caliceal group, creates the conditions for a relatively easy retrograde approach.

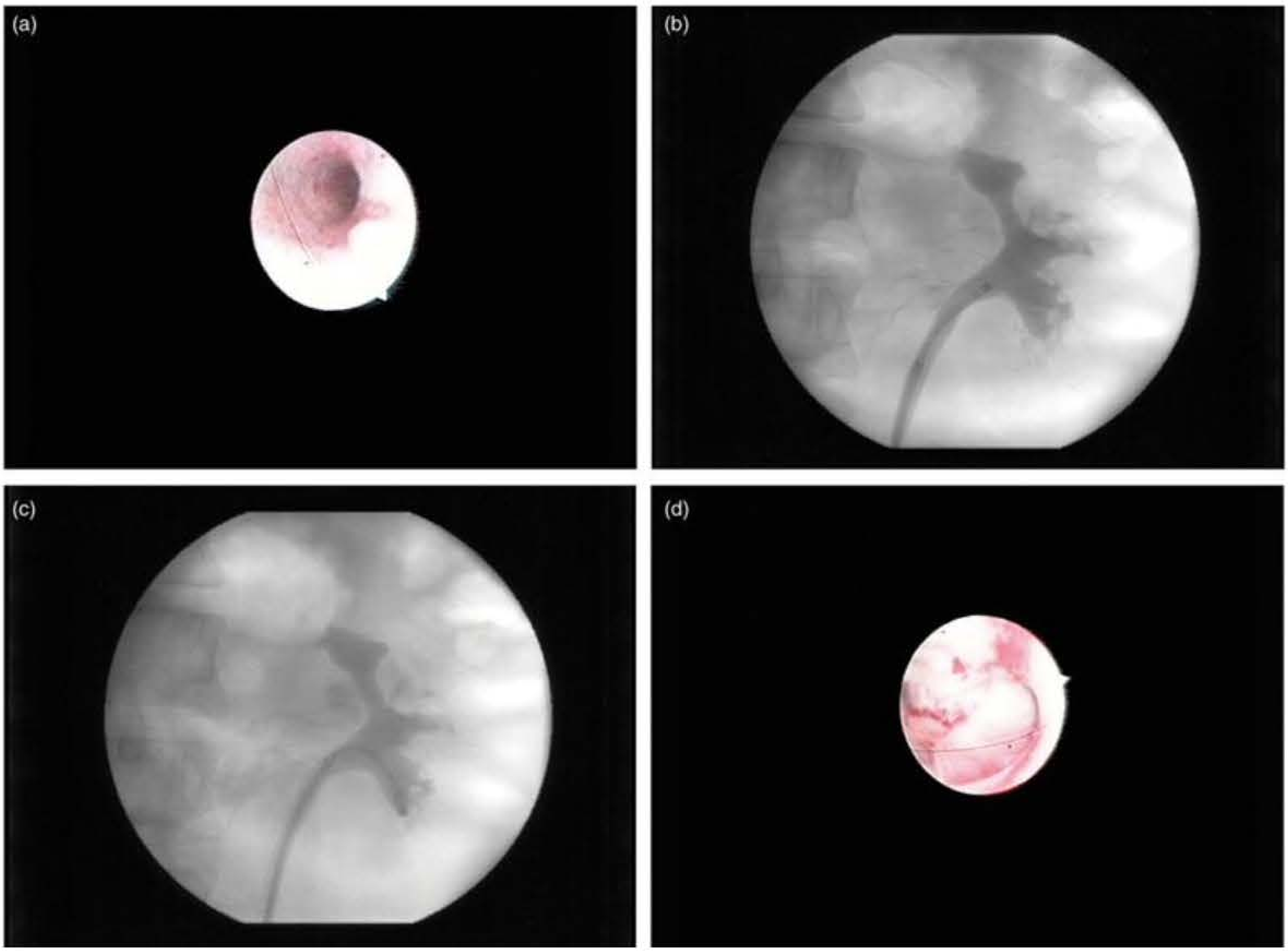
This method is generally reserved for symptomatic diverticula of small dimensions, up to 1.5 cm, with or without intradiverticular stones (Monga et al., 2004). Retrograde approach is preferred in patients with caliceal diverticula located anteriorly, which are difficult to approach percutaneously (Leveille and Bird, 2007).

7.3. Technique particularities

7.3.1. Identifying the Diverticular Neck

The position of the pyelocaliceal diverticulum will be determined by fluoroscopy, by injecting a contrast medium through the working channel of the flexible ureteroscope.

The distal end of the flexible ureteroscope will be maneuvered under fluoroscopic control at the level of the pyelocaliceal system toward the opacified diverticulum (Fig. 7.7).



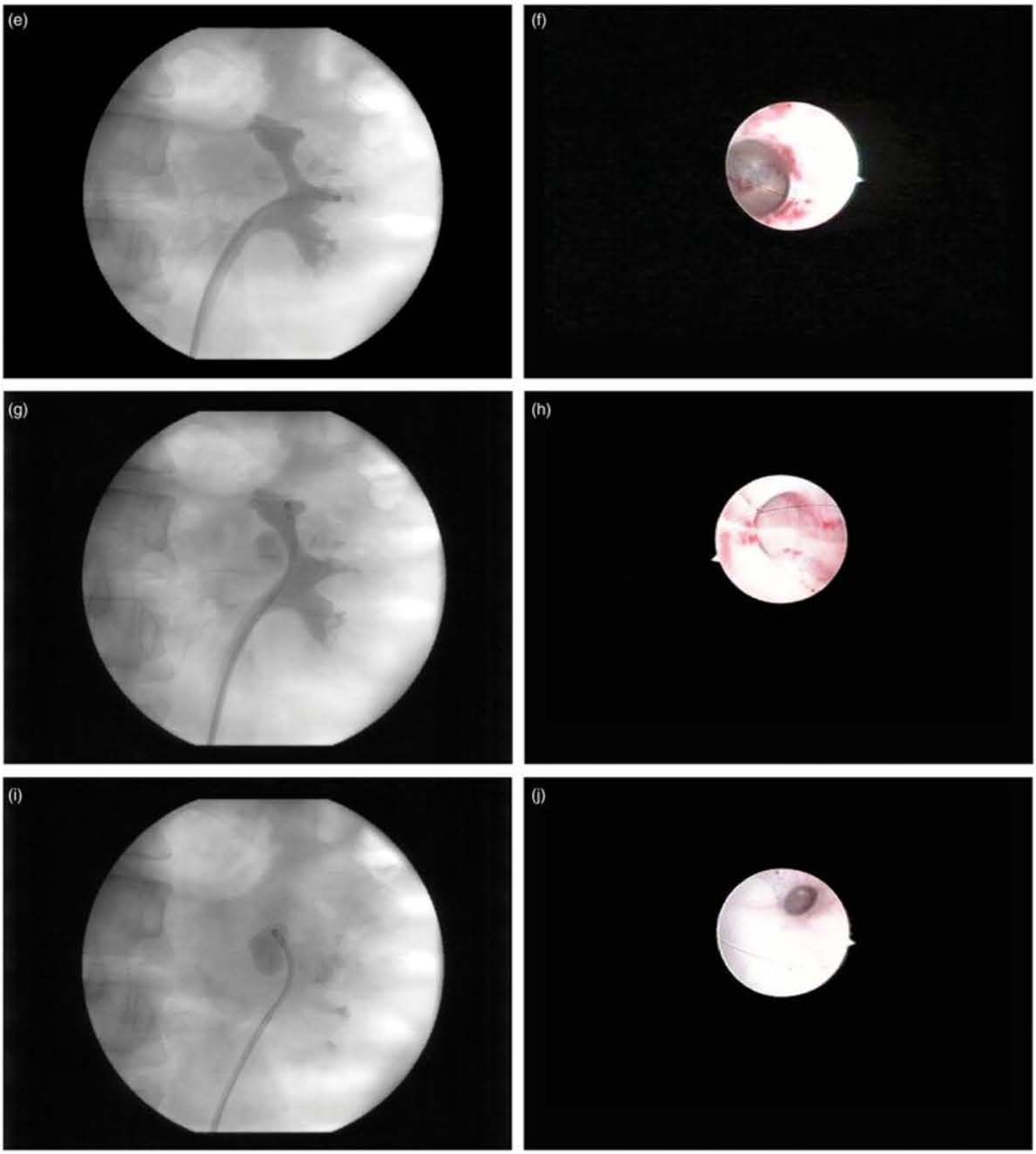


Figure 7.7 **Flexible ureteroscopic approach of an upper caliceal diverticulum.**
Lumbar ureter aspect (a), systematic inspection of the renal pelvis and of the caliceal groups (b–h), identifying the diverticular neck (i, j).

In this stage, the diverticular neck will be endoscopically highlighted and a guidewire inserted through the working channel of the flexible ureteroscope will be placed at this level (Fig. 7.8).

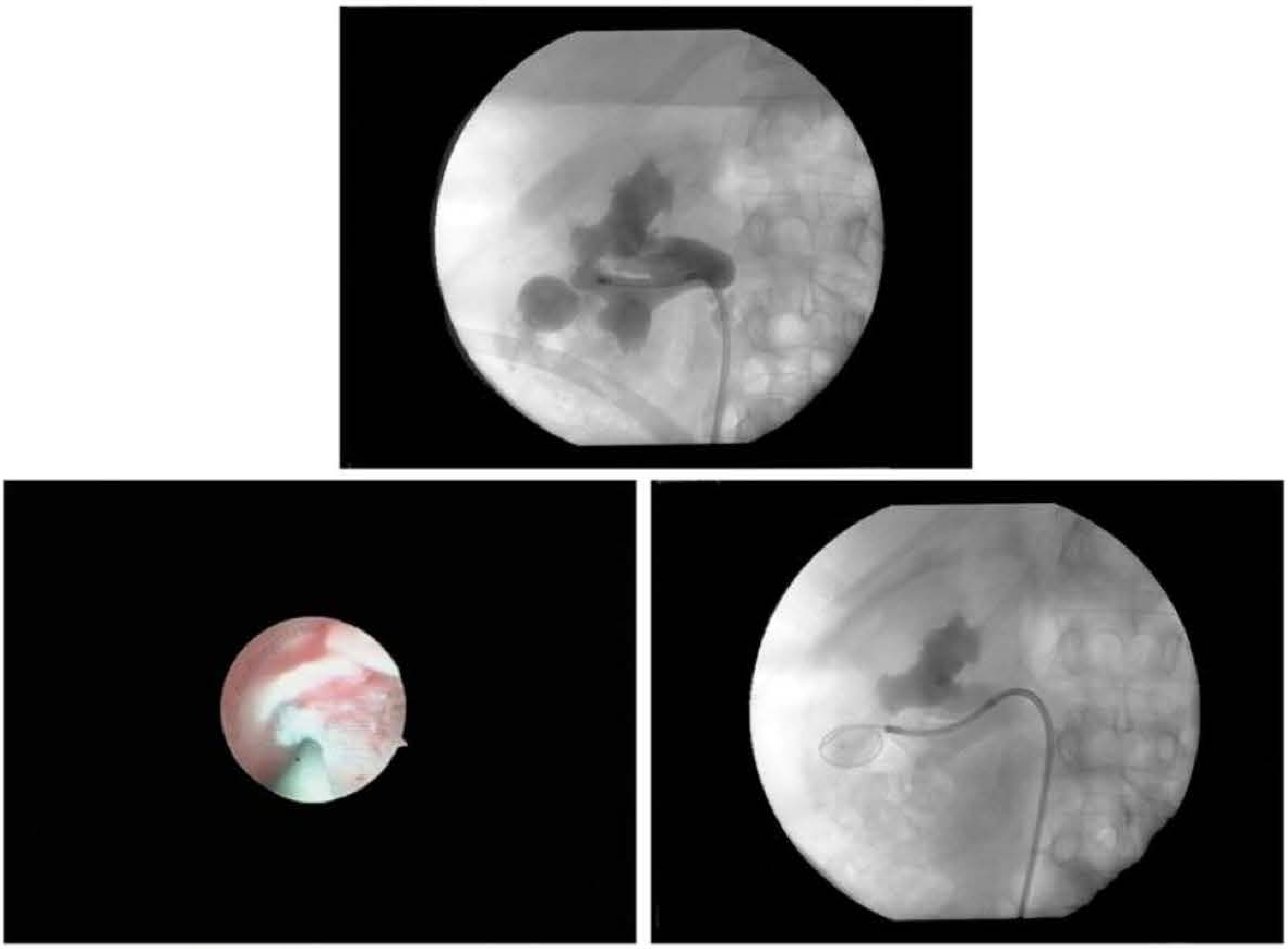


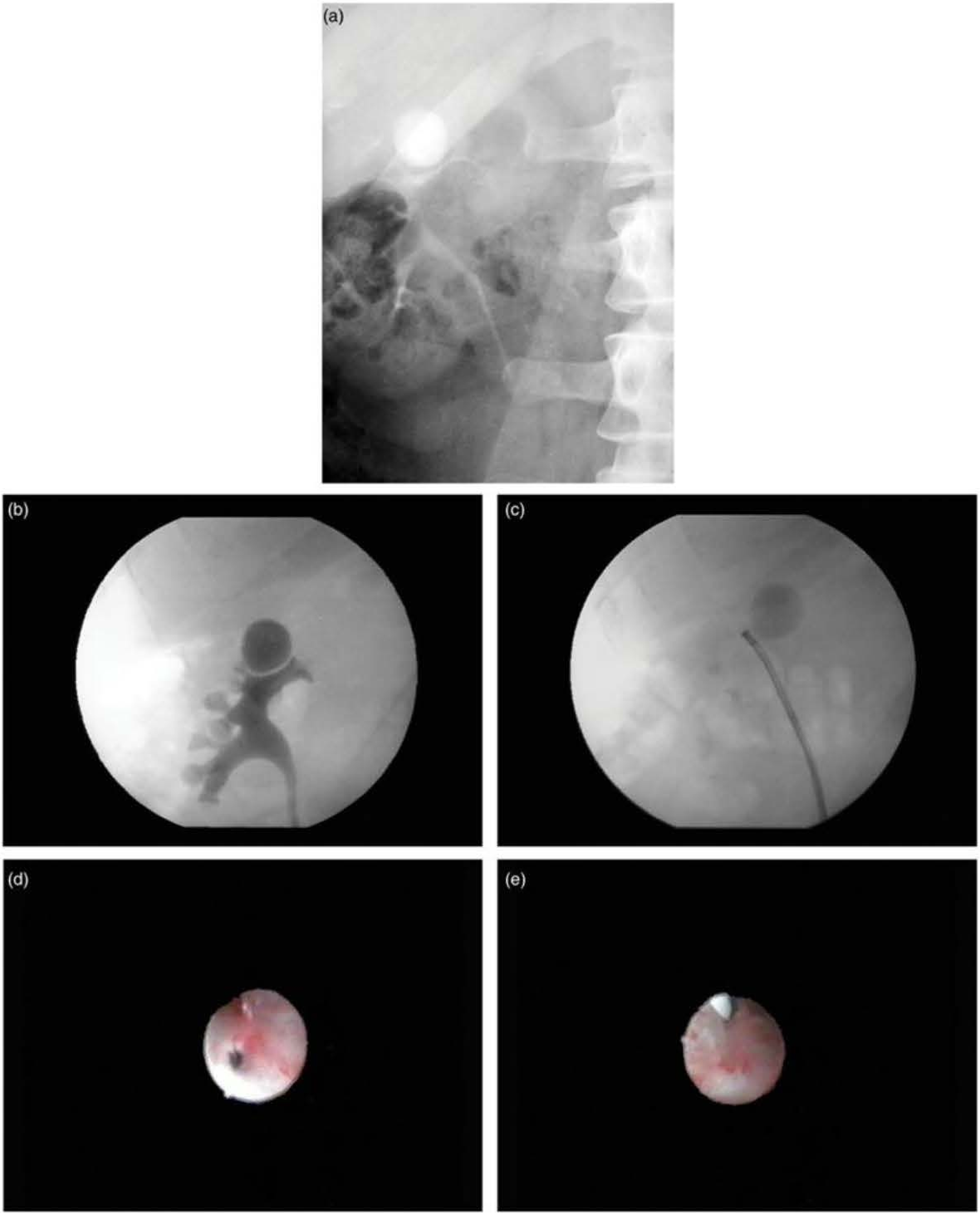
Figure 7.8 **Insertion of a metallic guidewire at the level of the diverticular neck.**

When the distal end of the guidewire is coiled at the diverticular level, the flexible ureteroscope is removed and reinserted alongside it.

7.3.2. Gaining Access to the Diverticular Cavity

The enlargement of the diverticular neck can be achieved through dilation using a balloon catheter up to 12 F, by Greenwald electrode incision, or in a more modern fashion by laser incision (Grasso et al., 1995a; Baldwin et al., 1998).

Lasers with pulsed (such as the Ho:YAG laser) or continuous (such as the Nd:YAG laser) emission can be used. The Ho:YAG laser is preferred for incision (Fig. 7.9) due to its safety (having a low tissue penetrability of just 0.5–1 mm) and also because it can be used subsequently for the lithotripsy of intradiverticular stones.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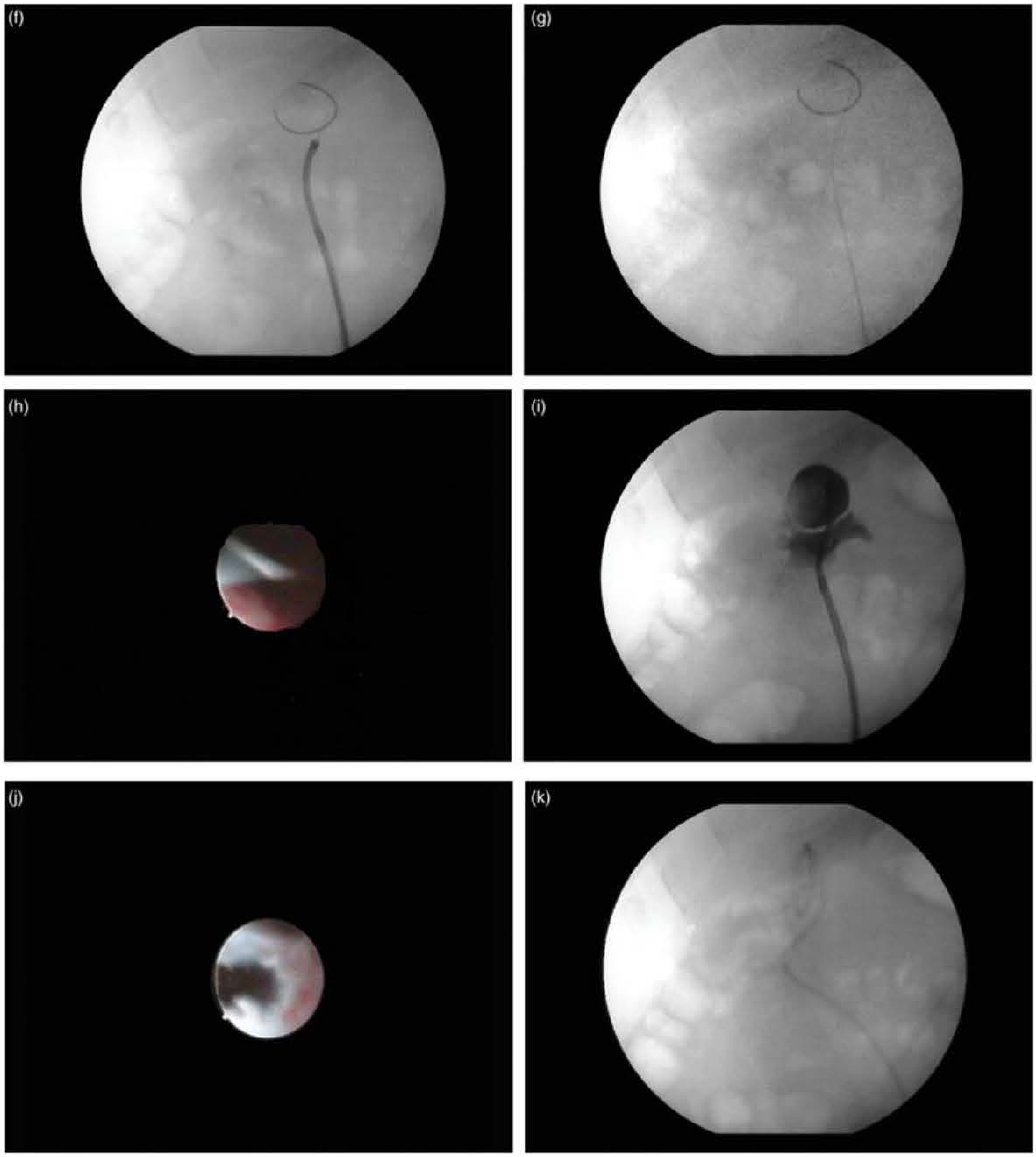
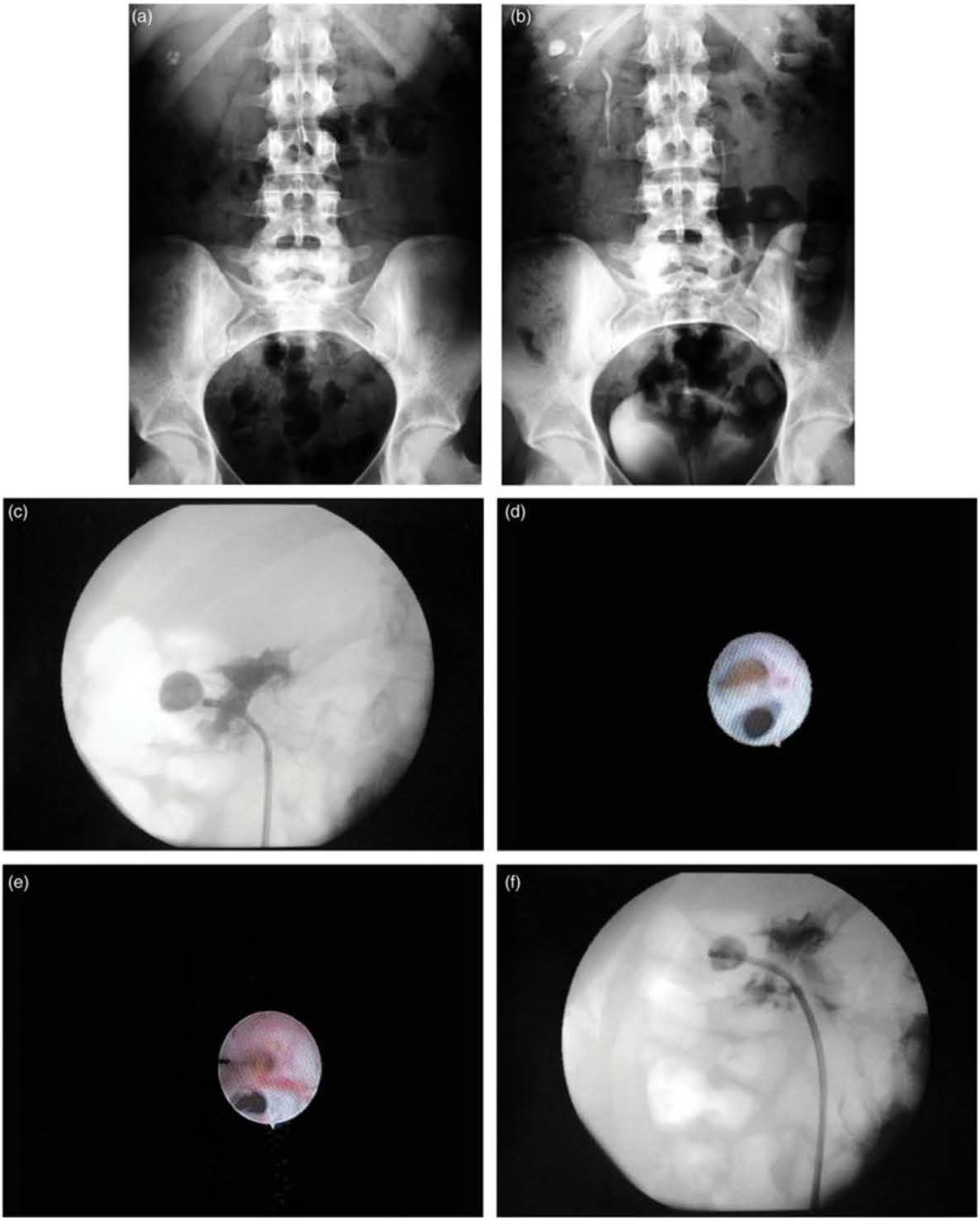


Figure 7.9 Flexible ureteroscopic approach of an upper caliceal diverticulum (a, b): identifying the diverticular neck (c, d), placing the safety guidewire inside the cavity (e–g), gaining access to the diverticular level through laser incision (h, i), large aspect of the neck at the end of the intervention (j), JJ catheter with the superior end at the diverticular level (k).

Multiple superficial incisions are made at 12, 3, 6, and 9 o'clock, which, compared with a single deep incision, have a reduced risk of bleeding by injuring an interlobar artery (Monga et al., 2004). Because of these relations between the caliceal infundibula and the intrarenal arterial system, some authors recommend that incisions be performed preferably in the superior/inferior quadrants, and never in the anterior one (Sampaio, 2007).

7.3.3. Lithotripsy and Intradiverticular Stones Extraction

Once access to the diverticulum's cavity is gained (Fig. 7.10), electrohydraulic (Fig. 7.11) or laser lithotripsy of the stone is performed, and the fragments are eventually extracted with basket catheters or flexible forceps.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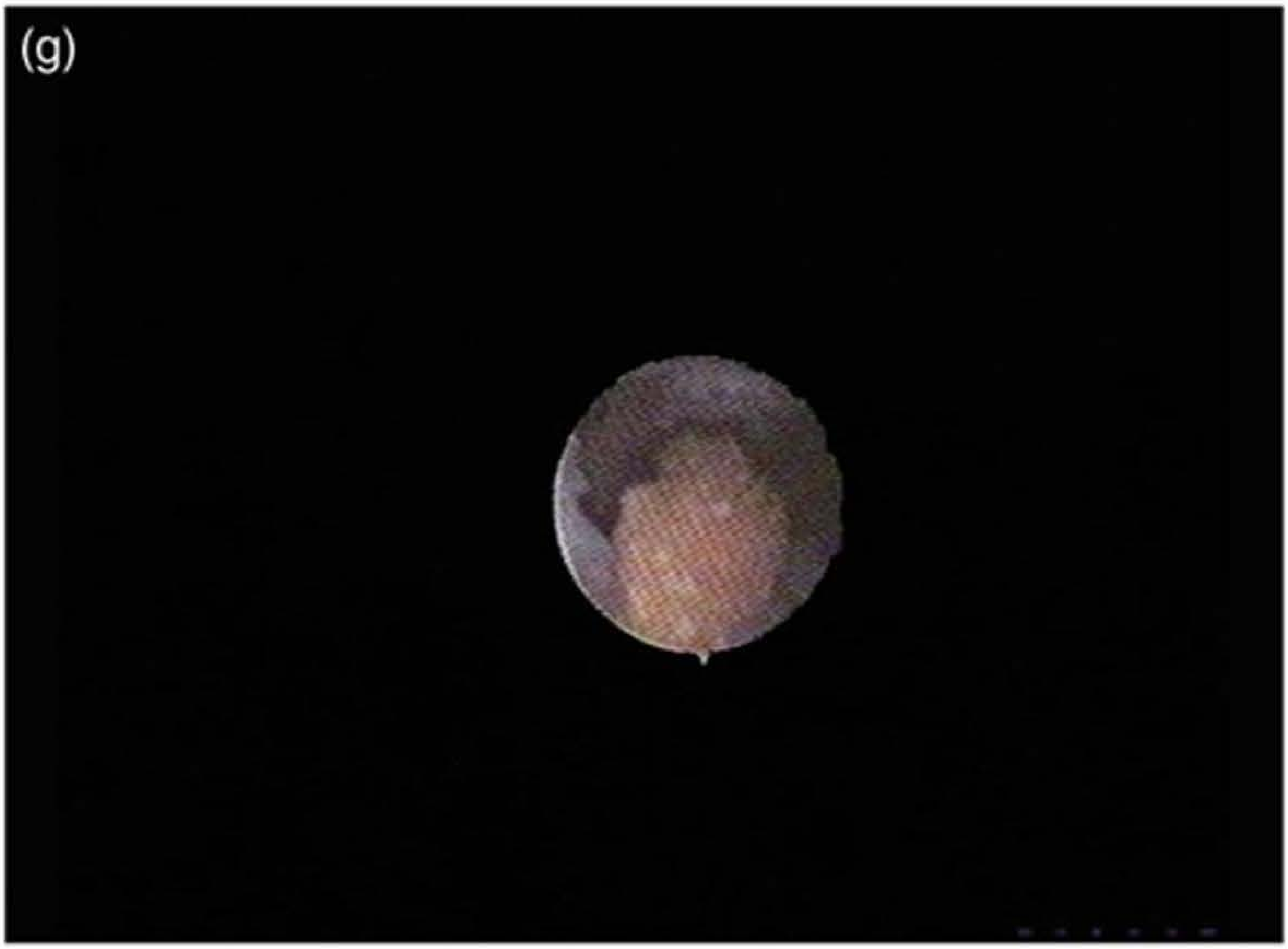
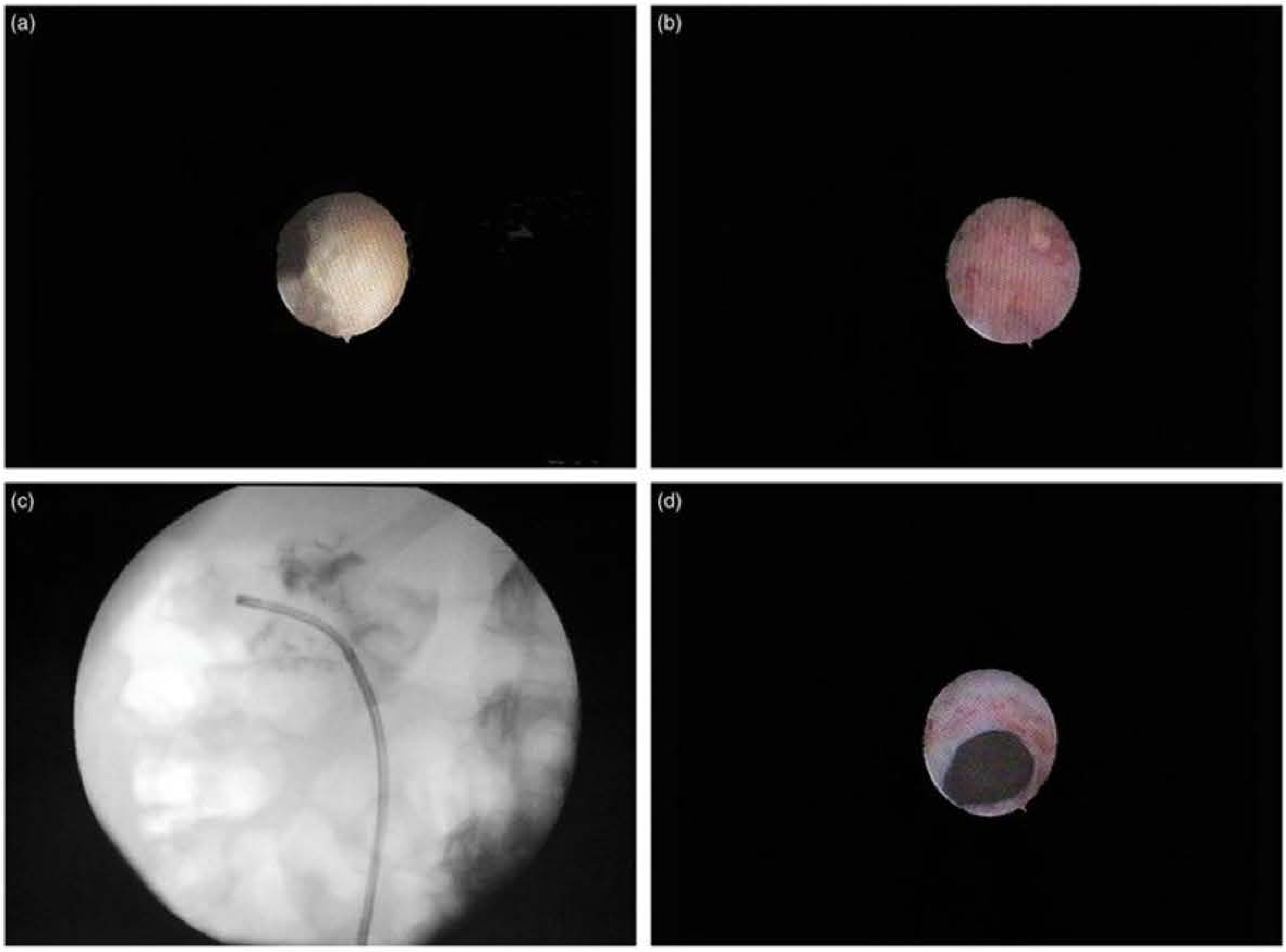


Figure 7.10 Flexible ureteroscopic approach of a middle caliceal diverticulum, with intradiverticular lithiasis (a, b): identification of a double neck (c, d), its electrical incision (e), gaining access to the cavity (f, g).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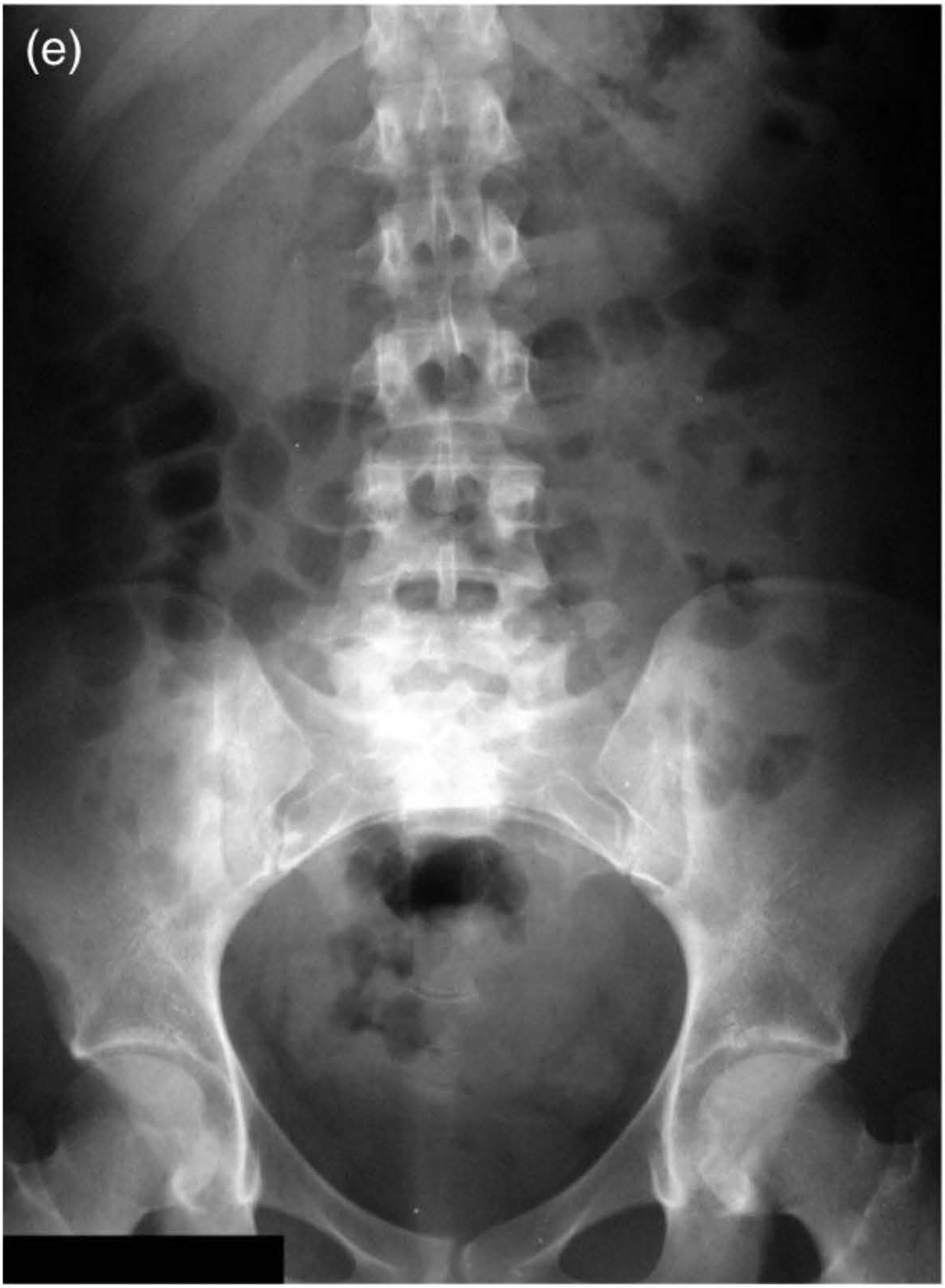

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Figure 7.11 **Electrohydraulic lithotripsy of the intradiverticular stone (a), “stone-free” aspect of the diverticulum (b, c), wide diverticular neck (d), final “stone-free” aspect (e).**

Tipless basket catheters, described in the section dedicated to the treatment of pyelocaliceal stones, are preferred also in this case (Fig. 7.12).

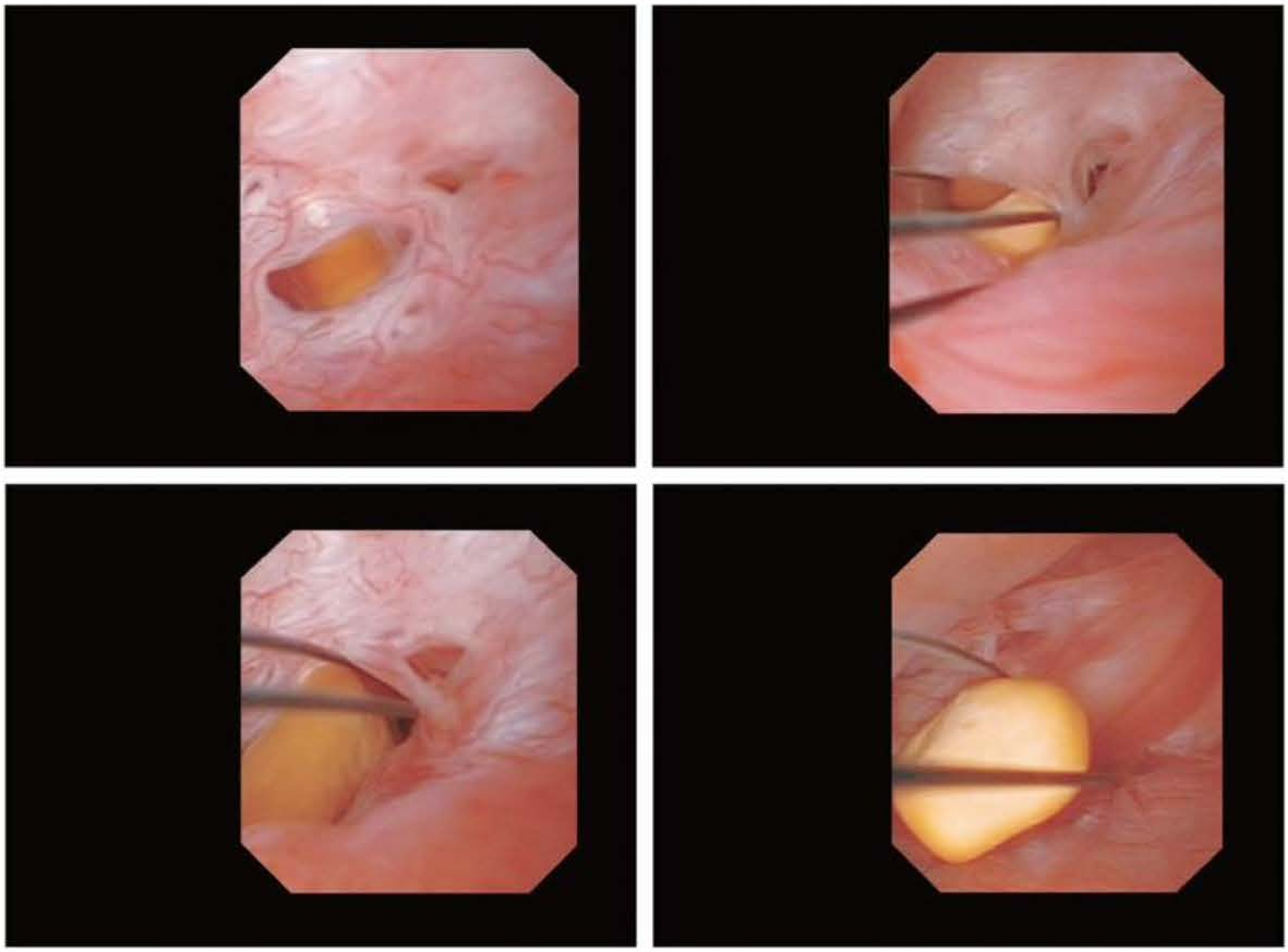


Figure 7.12 **Intradiverticular stone extraction with a tipless basket catheter.**

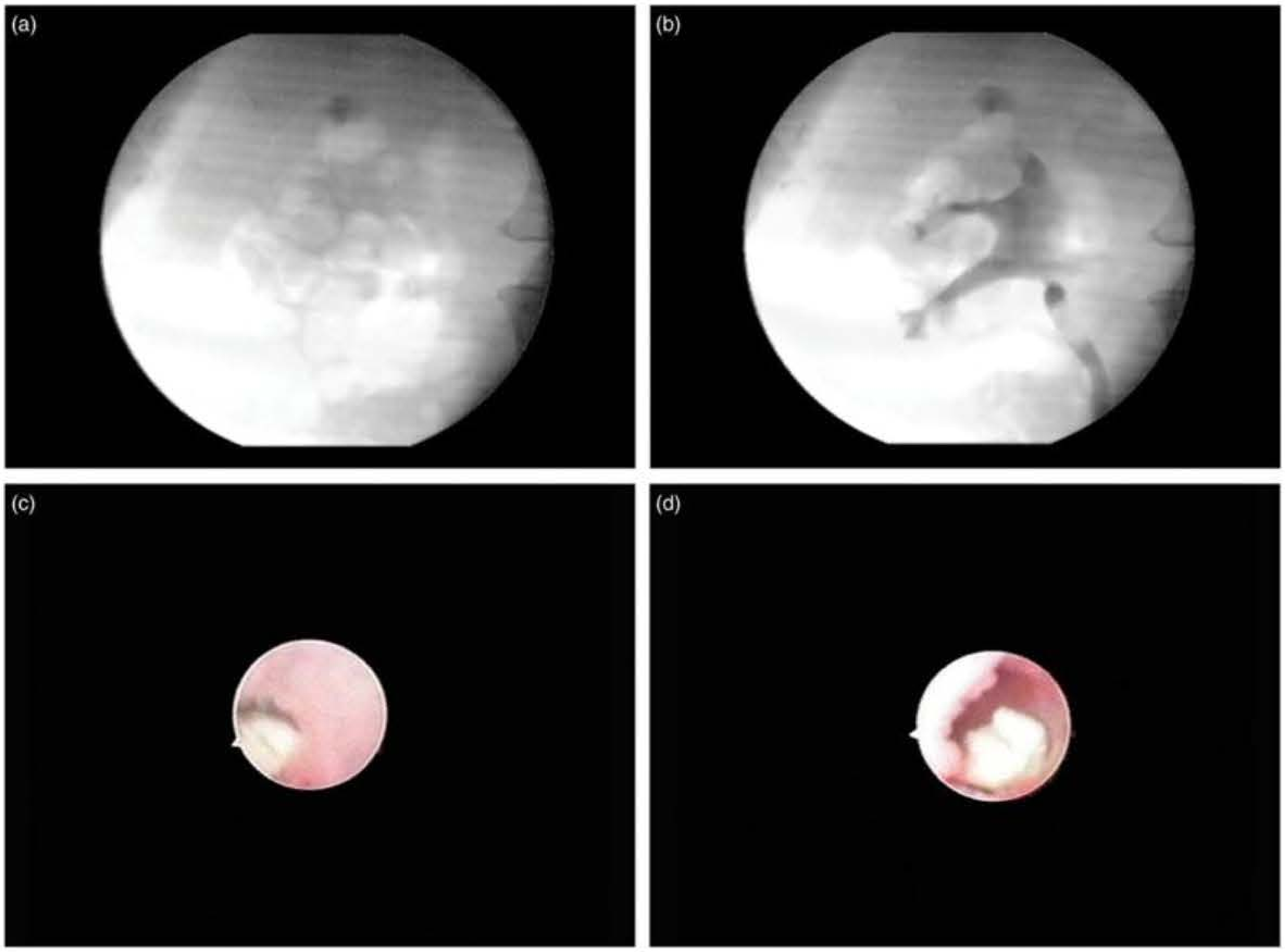
Grasso and coworkers described a combined retrograde and antegrade technique. Using a 7.5 F flexible ureteroscope, they gained access to the diverticulum's cavity by balloon dilation or incision of the neck and continued the intervention exclusively in a retrograde manner only in the case of small stones. For voluminous stones, direct percutaneous puncture of the diverticulum was performed, under combined fluoroscopic and endoscopic control, followed by antegrade lithotomy (Grasso et al., 1995b).

Another technique, described by Fuchs and David (1989), implies the extracorporeal lithotripsy of intradiverticular stones, after flexible ureterorenoscopic dilation of the neck.

7.3.4. Diverticulum Cavity Dissolution

Some authors recommend routine dissolution of the diverticular cavity, either through coagulation of the walls with a flexible electrode inserted through the ureteroscope or by discharging the unfocused Ho:YAG laser at this level, at a power of 1 J and a frequency of 15 Hz (Monga et al., 2004).

Other authors do not recommend this step, especially for small diverticula, considering that obtaining a large communication between the cavity and the pyelocaliceal system (Fig. 7.13) is sufficient for the long-term elimination of symptoms and for the prevention of lithiasis recurrence (Baldwin et al., 1998; Geavlete et al., 2006). According to Batter and Dretler (1997), there are no studies that can positively prove that fulguration of the nonsecretory diverticulum mucosa will determine the obliteration of its cavity.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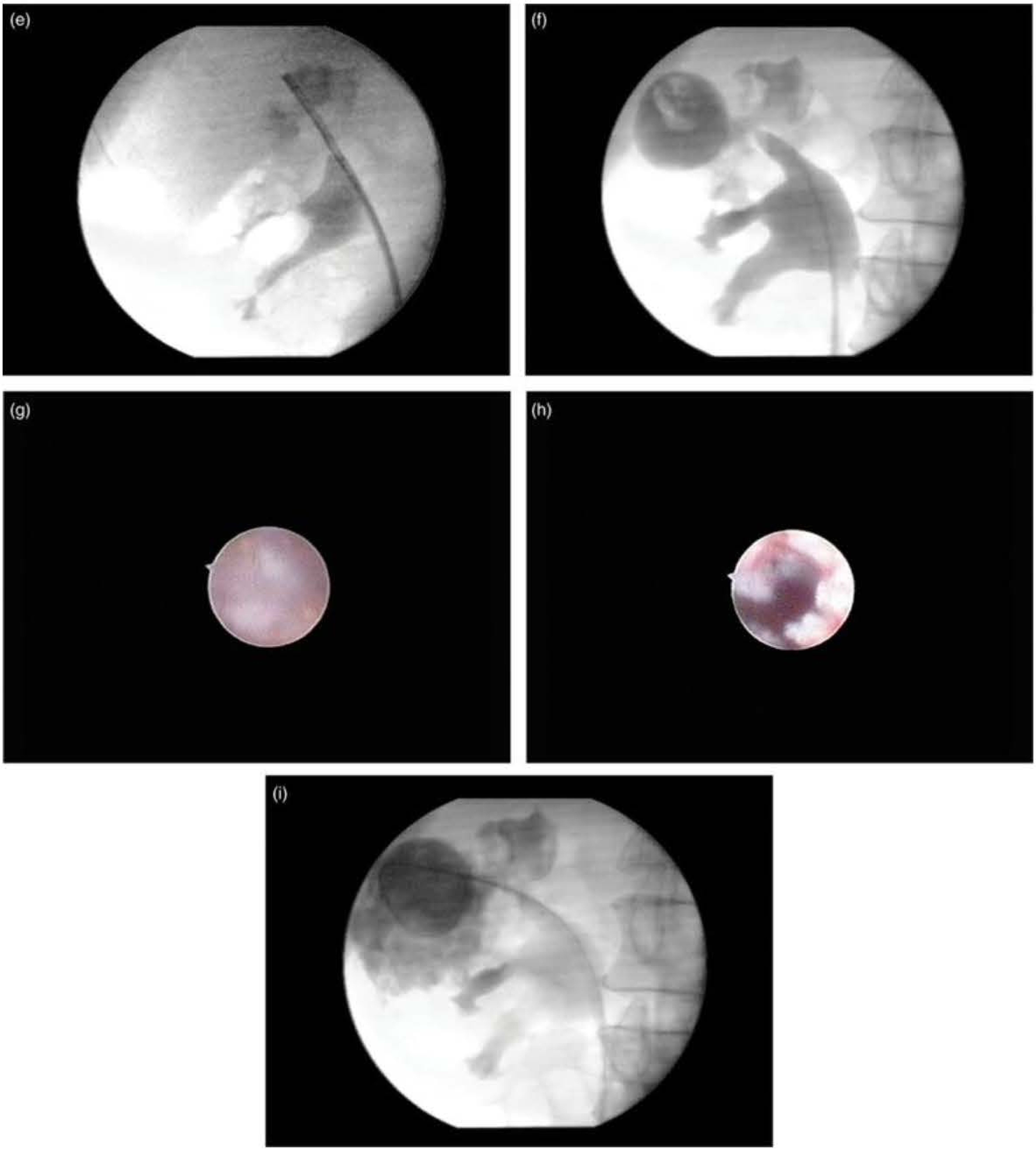
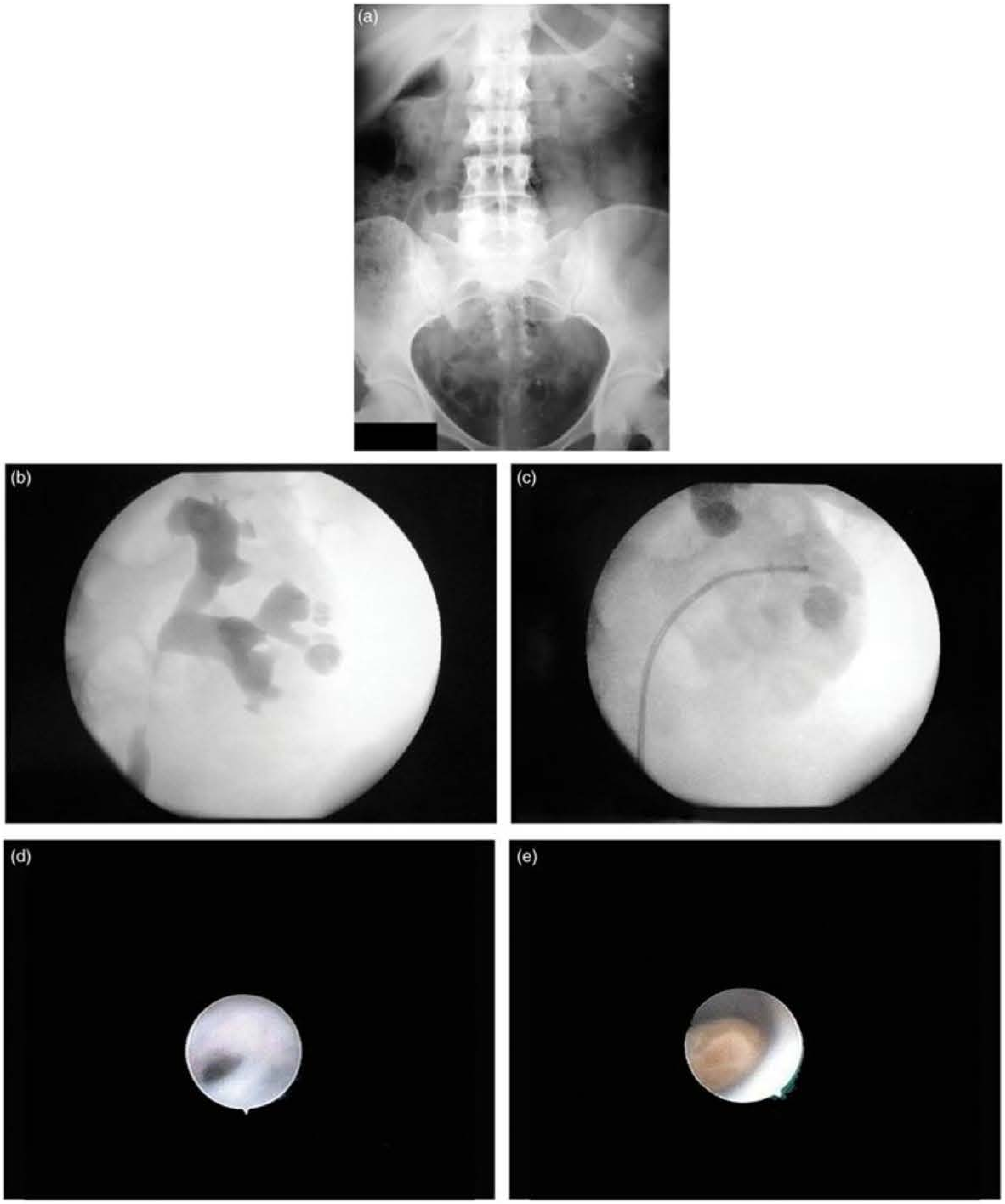


Figure 7.13 Flexible ureteroscopic approach of an upper caliceal diverticulum with impacted lithiasis at the neck (a–d), gaining diverticular access (e, f), “stone-free” aspect at the end of the intervention, with a wide neck (g–i).

7.4. Results

Flexible ureteroscopy can be an efficient therapeutic alternative for symptomatic pyelocaliceal diverticula, especially for those with dimensions of up to 1.5 cm (Figs 7.14 and 7.15) (Monga et al., 2004).



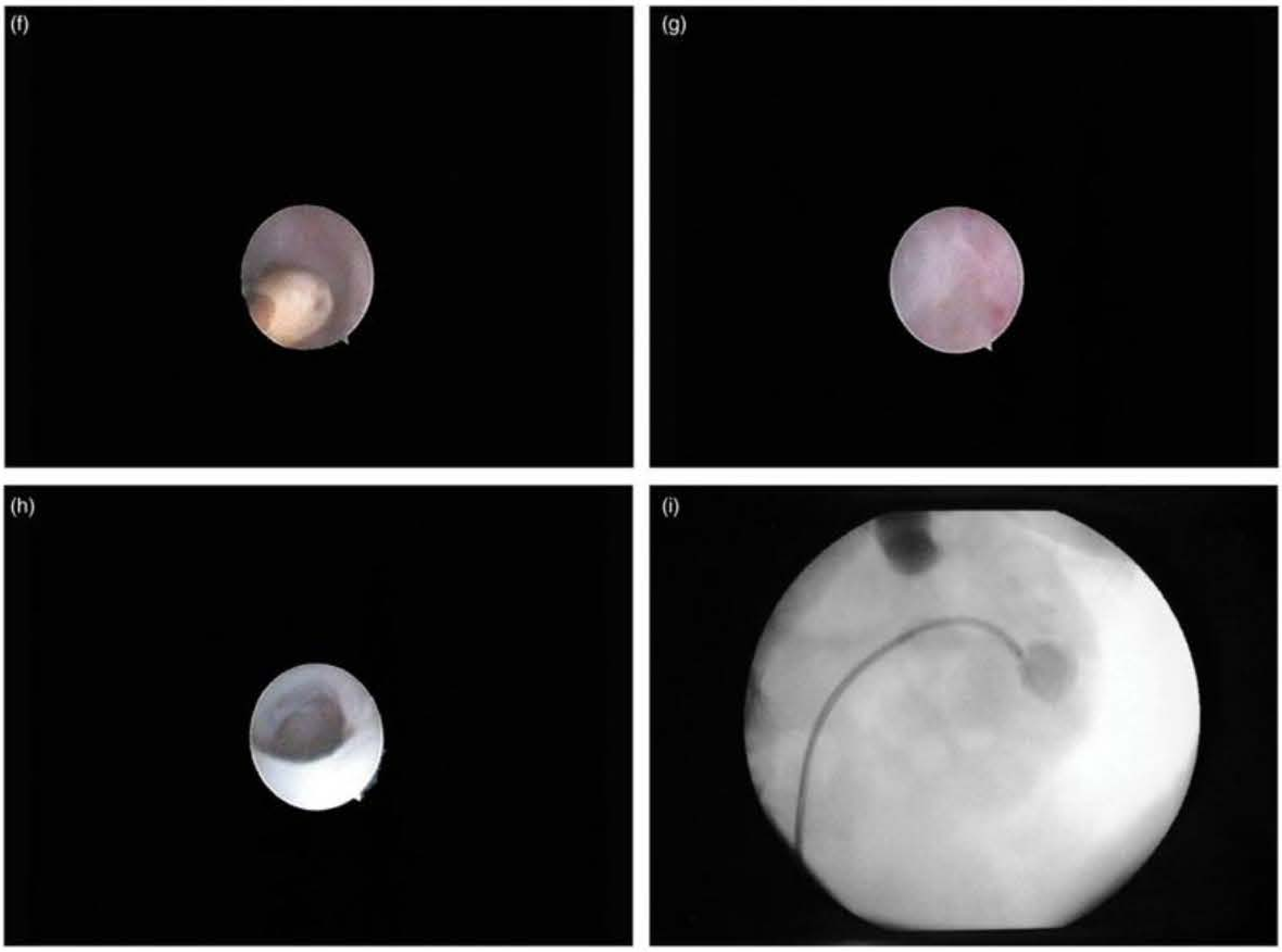
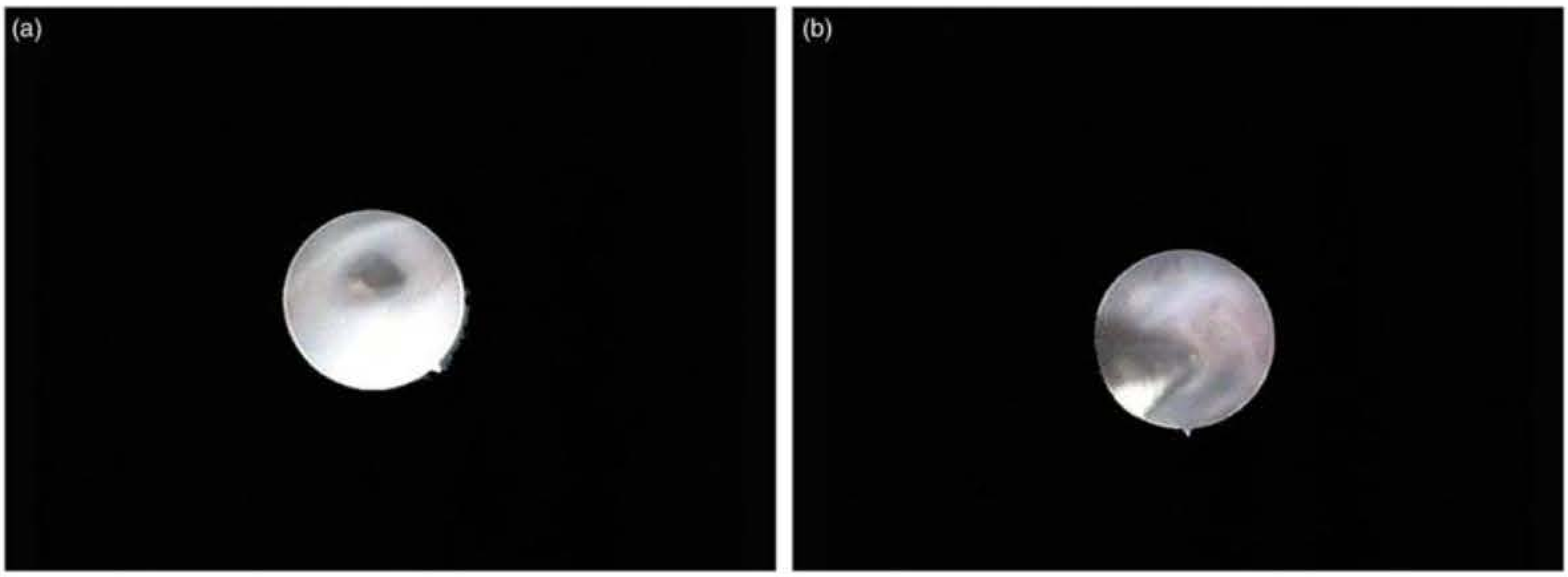
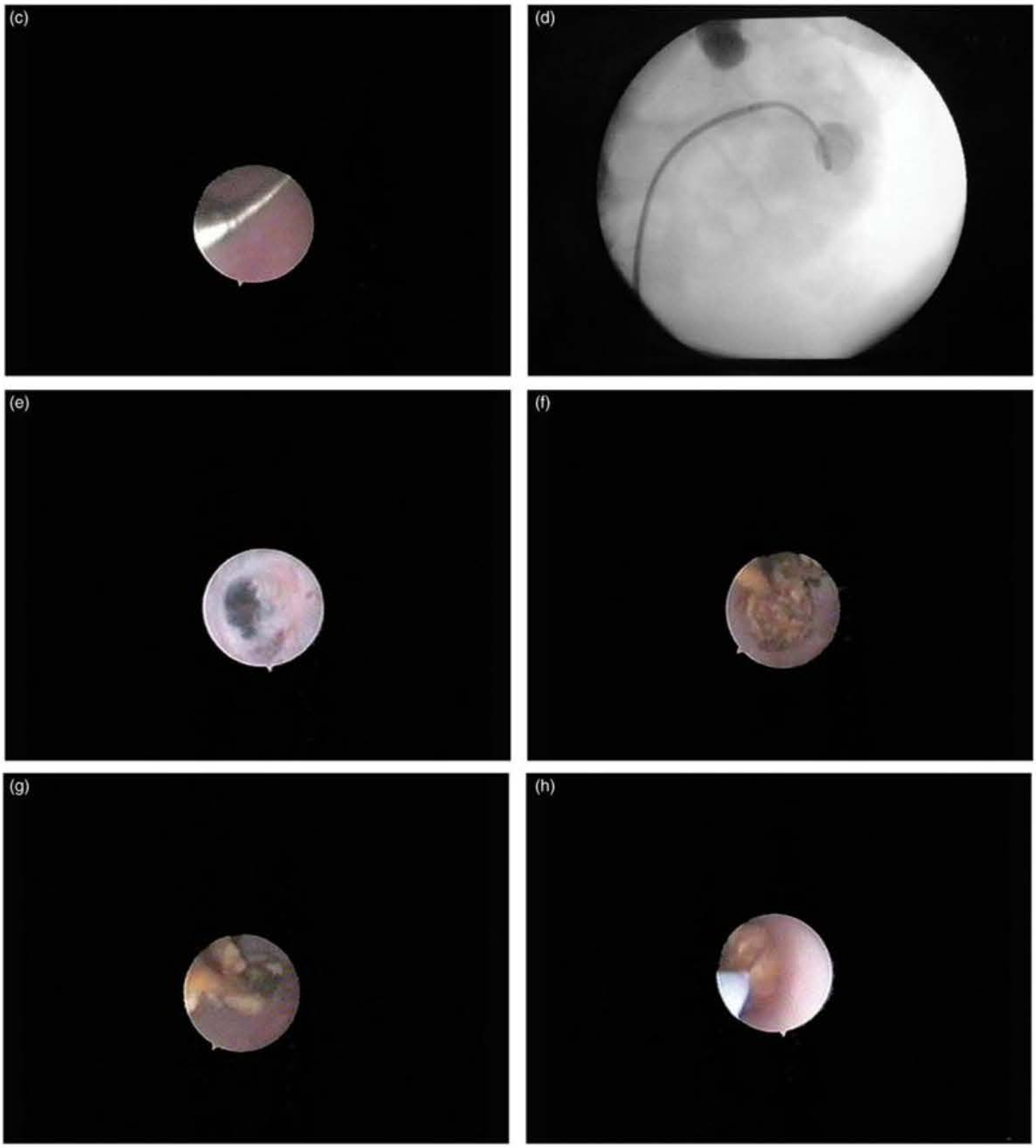


Figure 7.14 Flexible ureteroscopic approach in a patient with two left middle caliceal diverticula with intradiverticular lithiasis (a, b): identifying one of the diverticulum's neck (c, d), gaining diverticular access (e), electrohydraulic lithotripsy of the stone (f), final "stone-free" aspect, with a wide neck (g–i).

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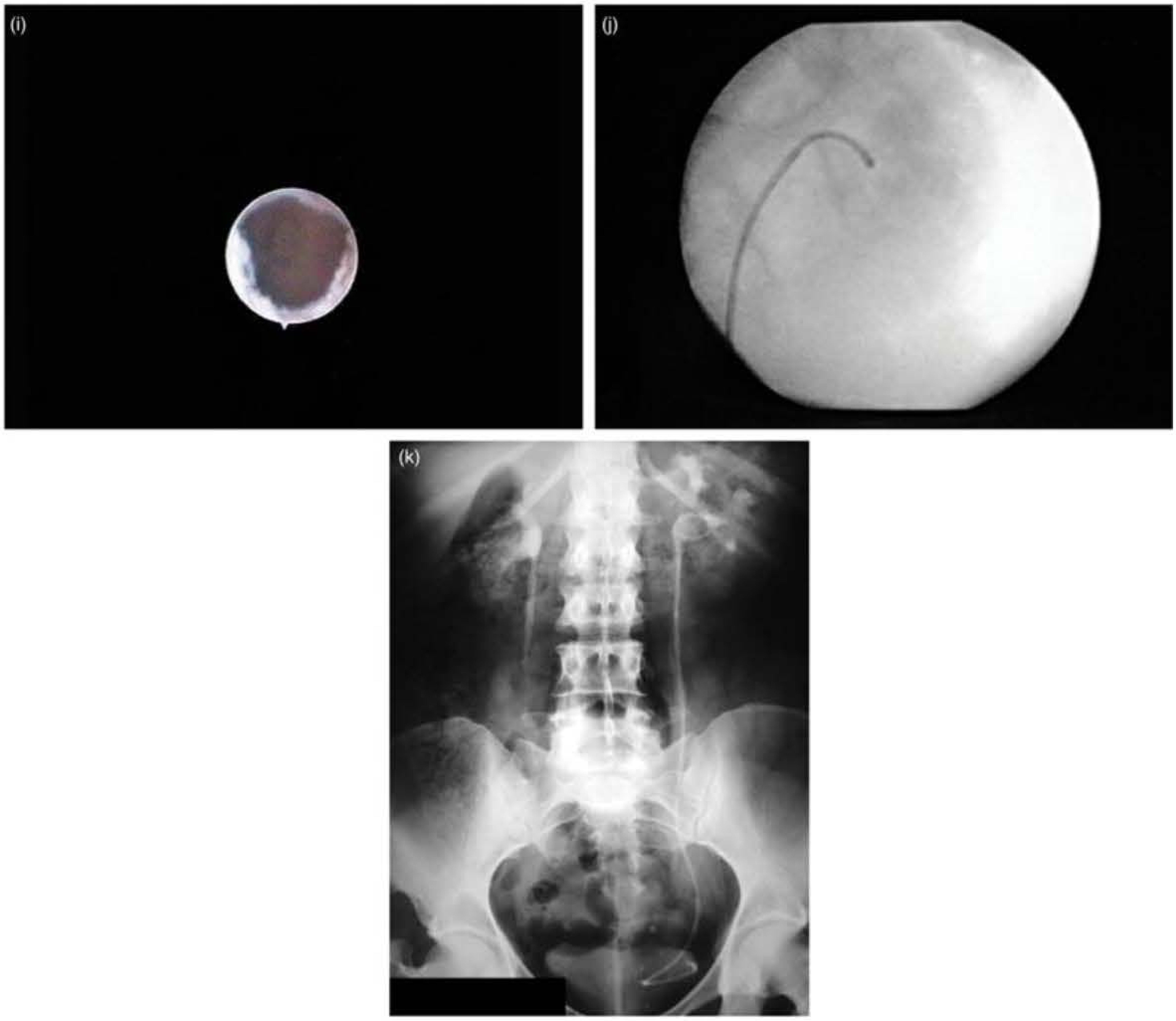

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Figure 7.15 **Continuing the intervention with the approach of the second diverticulum (a), gaining intradiverticular access through electric incision after placing the safety guidewire (b–e), electrohydraulic lithotripsy of the stones (f, g), extraction of the voluminous fragments with the tripod grasper (h), "stone-free" aspect, with a wide communication between the diverticulum and the pyelocaliceal system (i–k).**

The success of retrograde interventions depends on the position of the diverticula (Table 7.2). Thus, upper and middle caliceal diverticula can be identified and approached through flexible ureteroscopy in a significantly higher proportion than lower caliceal diverticula (84% vs. 29%) (Batter and Dretler, 1997; Geavlete et al., 2006).

Table 7.2

Results of Retrograde Flexible Ureteroscopic Approach in Patients with Pyelocaliceal Diverticula

		Success rate			
Author	**No. of patients**	**After one procedure**	**Upper and middle calyx**	**Lower calyx**	**Stone free**
Batter and Dretler (1997)	26	69.2%	84%	28.6%	69.2%
Baldwin et al. (1998)	9	89%	–	–	56%
Chong et al. (2000)	96	95%	–	–	90%
Auge et al. (2002)	17	35%	36%	0%	19%
Geavlete et al. (2006)	7	57.1%	75%	33%	57.1%

For intradiverticular stones, once the neck has been identified and access to the cavity has been obtained, stone-free rates of up to 83–95% can be obtained (Bellman et al., 1993; Monga et al., 2004).

After a mean follow-up period of 45 months, Batter and coworkers reported the absence of symptoms in all patients in whom retrograde access to the diverticulum was possible (Batter and Dretler, 1997).

8.1. Generalities

The continuous development of endourological techniques has led to their use as an alternative for upper urinary tract tumoral lesions. Thus, the progress regarding the equipment and the endoscopic techniques, as well as the improved intraoperative performances, have determined the increase of the importance of endoscopy as an alternative therapeutic method for urothelial neoplasms of the upper urinary tract.

While the standard treatment for transitional cell carcinoma of the upper urinary tract (TCC) is typically nephroureterectomy with perimeatic cystectomy (Fig. 8.1), conservative treatment may be a viable option for carefully selected cases. Moreover, the emergence and continuous development of equipment and of endourological techniques have created the conditions for conservative surgery to be used more and more frequently with superior results, by increasing diagnostic accuracy and by a better selection of patients (Abdel-Razzak et al., 1993; Grasso and Bagley, 1994; Keeley, 1997a; Martinez-Pineiro et al., 1996; Elliot et al., 1996).

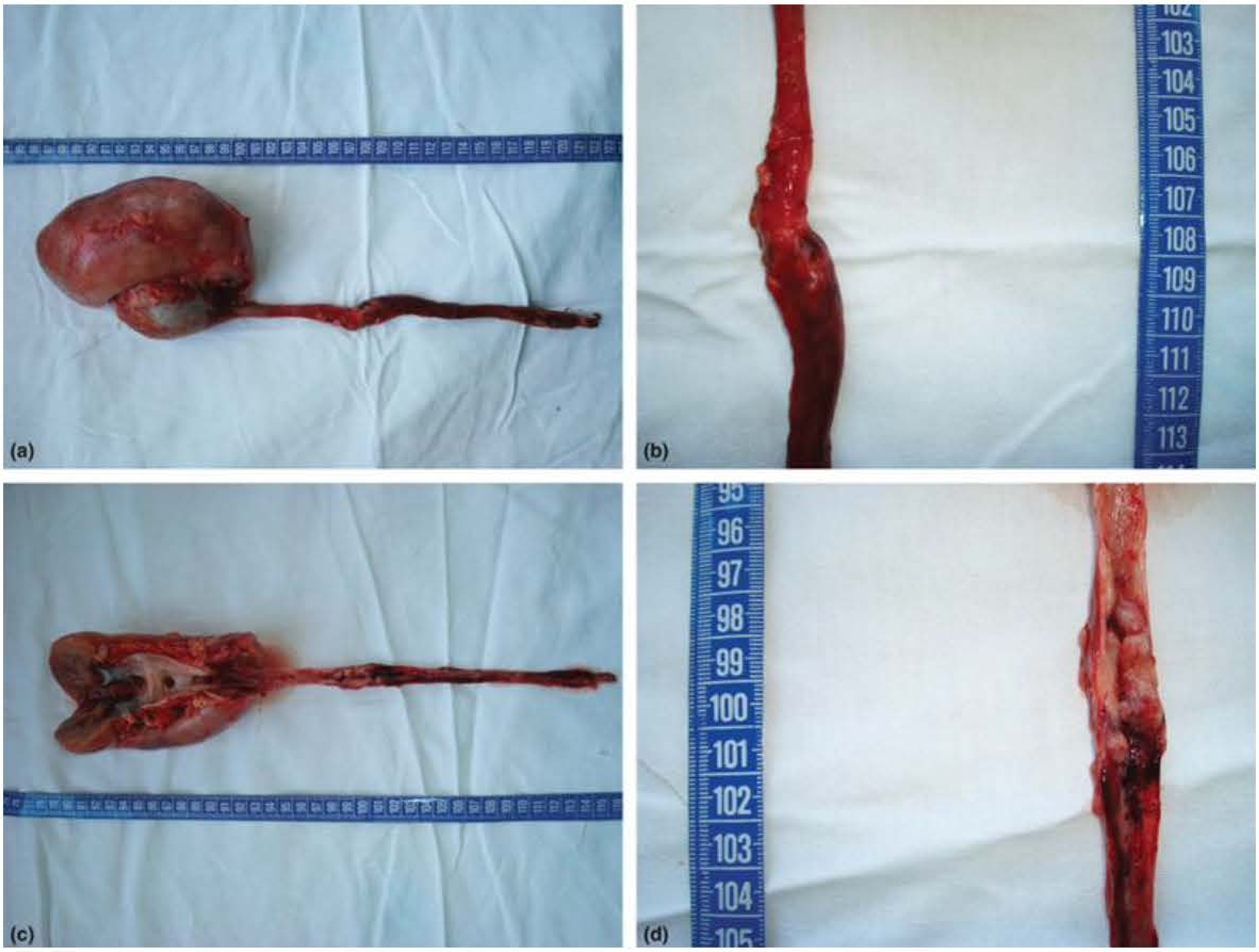

Figure 8.1 **Nephroureterectomy specimen with endoscopic perimeatic cystectomy (a) for ureteral tumor (b–d).**

Endourological techniques have been used for the treatment of TCC in patients with contraindications for nephroureterectomy since the 1980s. Huffman et al. (1985) reported the first case of urothelial tumor treated by ureteroscopic resection.

A short time later, Streem and Pontes (1986) published the first case of percutaneous approach for the treatment of a renal pelvis urothelial tumor. These techniques were later developed and popularized by Smith et al. (1987), who first used local (topical) immunotherapy as adjuvant therapy after tumor resection.

Regarding the type of energy used for tumor destruction, electroresection, fulguration, or laser vaporization can be used. The access can be retrograde (using a rigid or flexible ureteroscope) or antegrade. The percutaneous approach of TCC located in the intrarenal collecting system may be an acceptable alternative to nephroureterectomy (Bagley, 1996). The advantages of this type of approach are the result of the relatively easy access to all the segments of the upper urinary tract, as well as of the possibility of using a wider variety of instruments through a larger path of approach than the retrograde one.

The incidence of TCC is relatively low, accounting for approximately 5% of urothelial tumors. The ureteral location is more frequent than the pyelocaliceal one. The highest incidence is described for distal ureteral tumors (75%). Middle (25%) or proximal (5%) ureteral locations are less common (Messing, 2002) (Fig. 8.2).

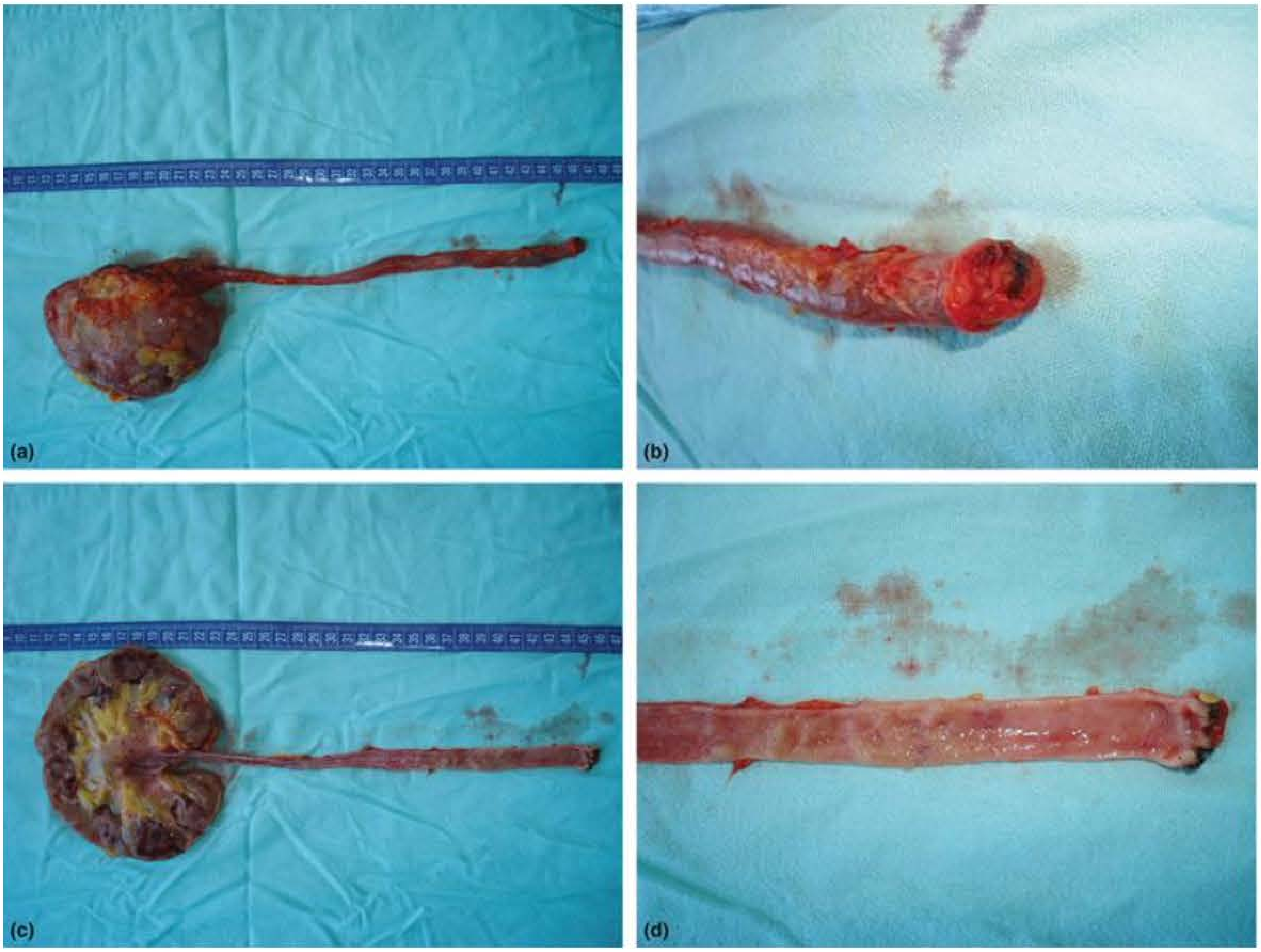

Figure 8.2 **Nephroureterectomy specimen (a, b) for multiple distal ureteral tumor (c, d).**

The incidence of TCC is increased in the sixth and seventh decades of life. Men are affected twice as frequently as women, the incidence being two times higher in Caucasians compared to Afro-Americans. One third of the tumors are multifocal. Tumors with simultaneous bilateral location are found in 2–5% of patients. Metachronous lesions are described in 2–9% of cases with nephroureterectomy. Among patients with bladder tumors, 2–4% may have TCC (Shinka et al., 1988). The risk of developing bladder tumors after the diagnosis of a TCC is significant, with an estimated incidence between 30% and 50% (Rabbani et al., 2001). The probability of a TCC occurring in patients with bladder tumors and carcinoma *in situ* (CIS) is reduced. TCC recurrences are usually ipsilateral.

Risk factors include: smoking, abuse of analgesic drugs, exposure to carcinogens (chemical, petrochemical and plastics industries, mining, tar, cocaine, aniline), cyclophosphamide treatment, history of upper urinary tract infections and lithiasis, and factors related to family habits (Messing, 2002). The association with Balkan nephropathy is recognized, but the lesions that occur in these patients are less aggressive.

8.2. Diagnosis and staging

The most common symptom is represented by microscopic or macroscopic hematuria, which occurs in 70–90% of cases. The following symptom with regard to frequency is lumbar pain, which occurs in 30% of patients as a consequence of ureteral obstruction by clots or tumoral fragments. Incidental discovery of a tumor during an imaging scan is described in 10–15% of cases. Approximately 10–20% of patients have a palpable lumbar tumor mass (secondary hydronephrosis or the tumor). The general signs are represented by weight loss, anorexia, and bone pains, and are rarely present in the initial stages, their presence indicating an advanced stage of disease.

8.2.1. Imaging Diagnosis

Radiological explorations represent the main diagnostic modality. Approximately 50–70% of patients with TCC have lacunar images on intravenous urography (IVU) (Figs 8.3 and 8.4).

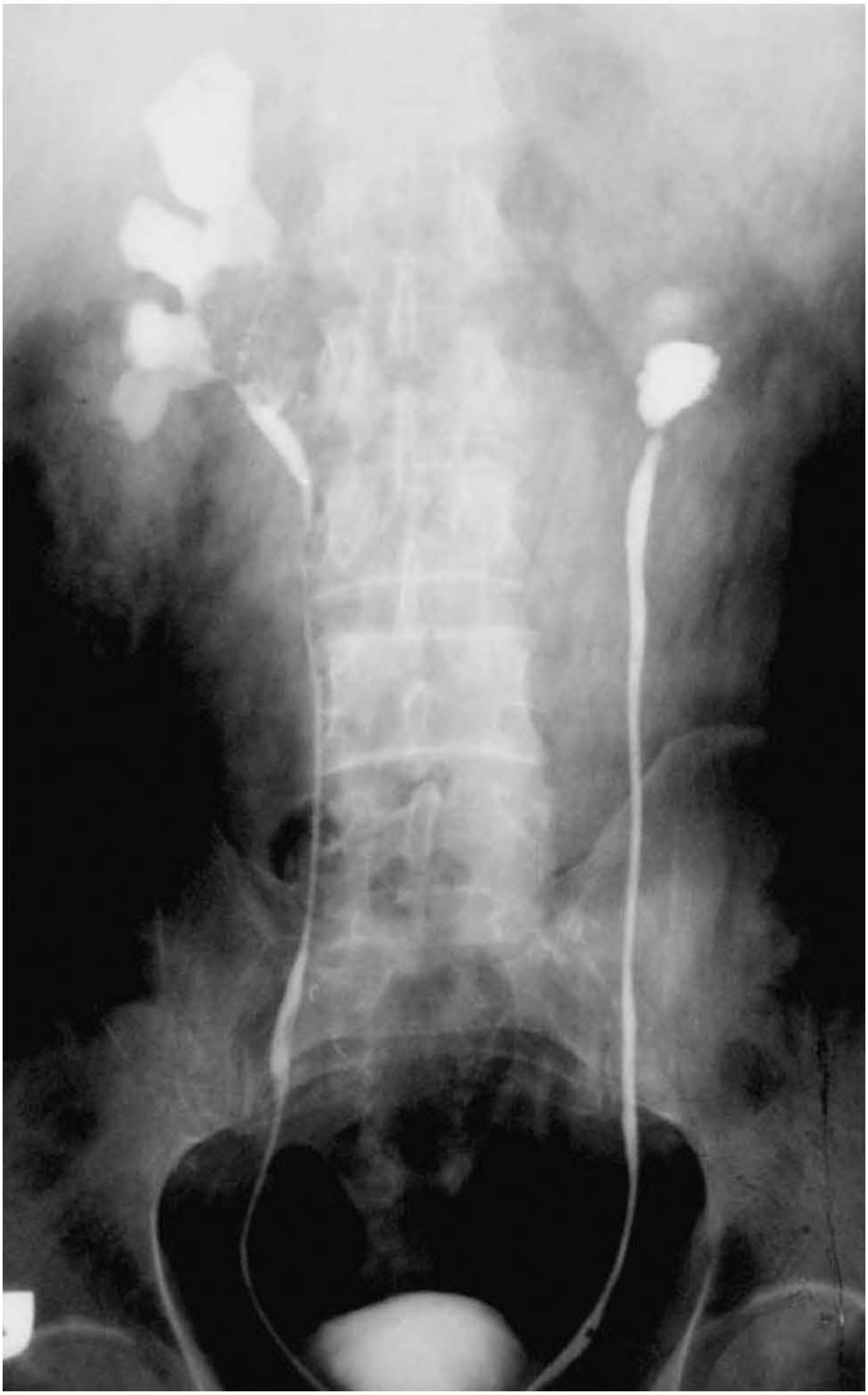

Figure 8.3 Filling defect of the right renal pelvis (IVU).

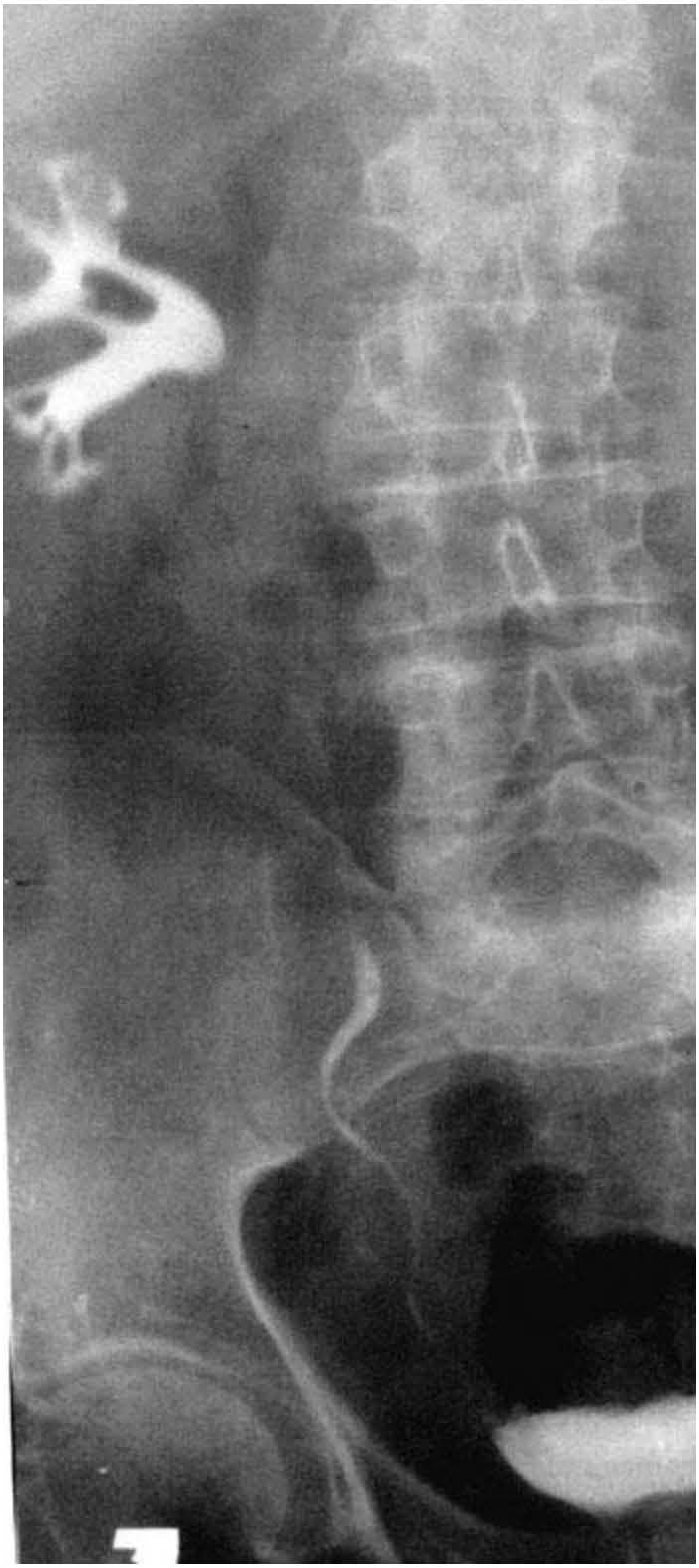

Figure 8.4 Right pyelocaliceal lacunar images (IVU).

However, less than half of the filling defects seen on IVU prove to be malignant (Bagley and Rivas, 1990). The urographic differential diagnosis is made with benign conditions: radiolucent stones, blood clots, fibroepithelial ureteral polyps (Fig. 8.5), irregular renal papillae, nephrogenic adenomas, subepithelial hematomas, extrinsic vascular compressions, cystic pyelitis or ureteritis, tuberculosis, endometriosis, and amyloidosis.

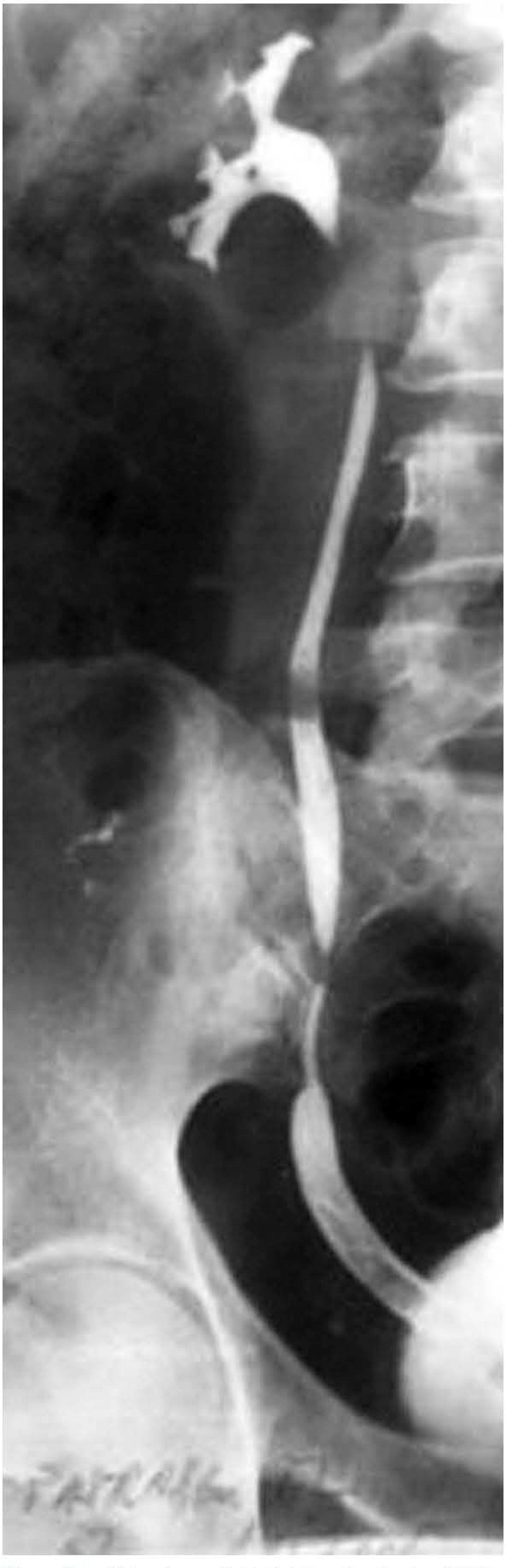

Figure 8.5 Voluminous right distal ureteral polyp (IVU).

Retrograde pyelography is indicated if there is a poor visualization of the upper urinary tract or when the contrast agent cannot be administered intravenously (allergic patients, renal failure, or urographic nonfunctioning kidney) (Fig. 8.6). Although this method provides a diagnostic accuracy of approximately 75% (Murphy et al., 1981), false-negative results are described with an incidence of 25% (Keeley, 1997a). It is generally recommended to use a diluted contrast agent for retrograde ureteropyelography (1/2–1/3 compared to the initial concentration) in order to allow the visualization of the filling defects (Fig. 8.7).

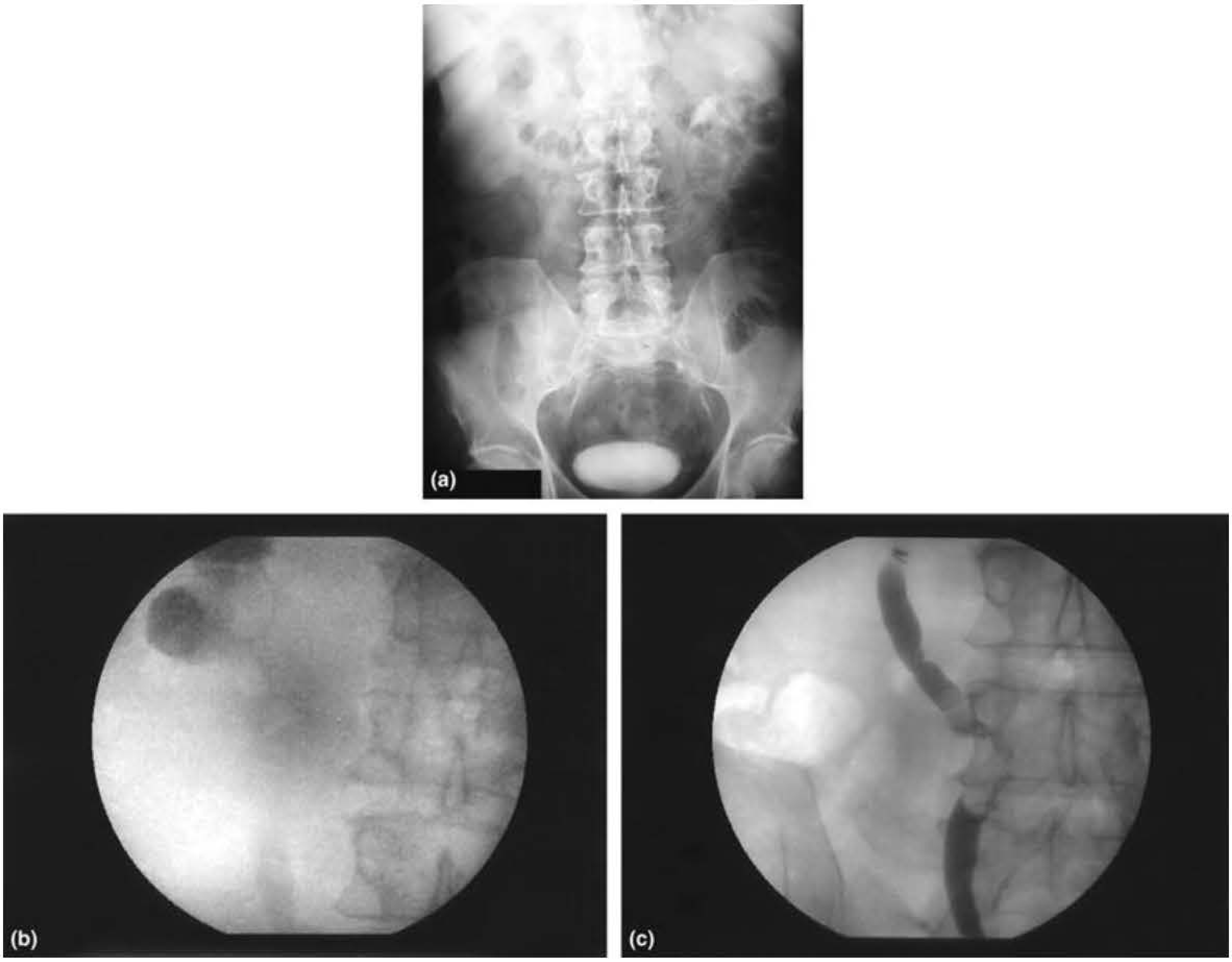

Figure 8.6 Urographic nonfunctioning right kidney in a patient with total hematuria (a), retrograde ureteropyelogram showing right hydronephrosis (b), and a filling defect of the middle ureter (c).

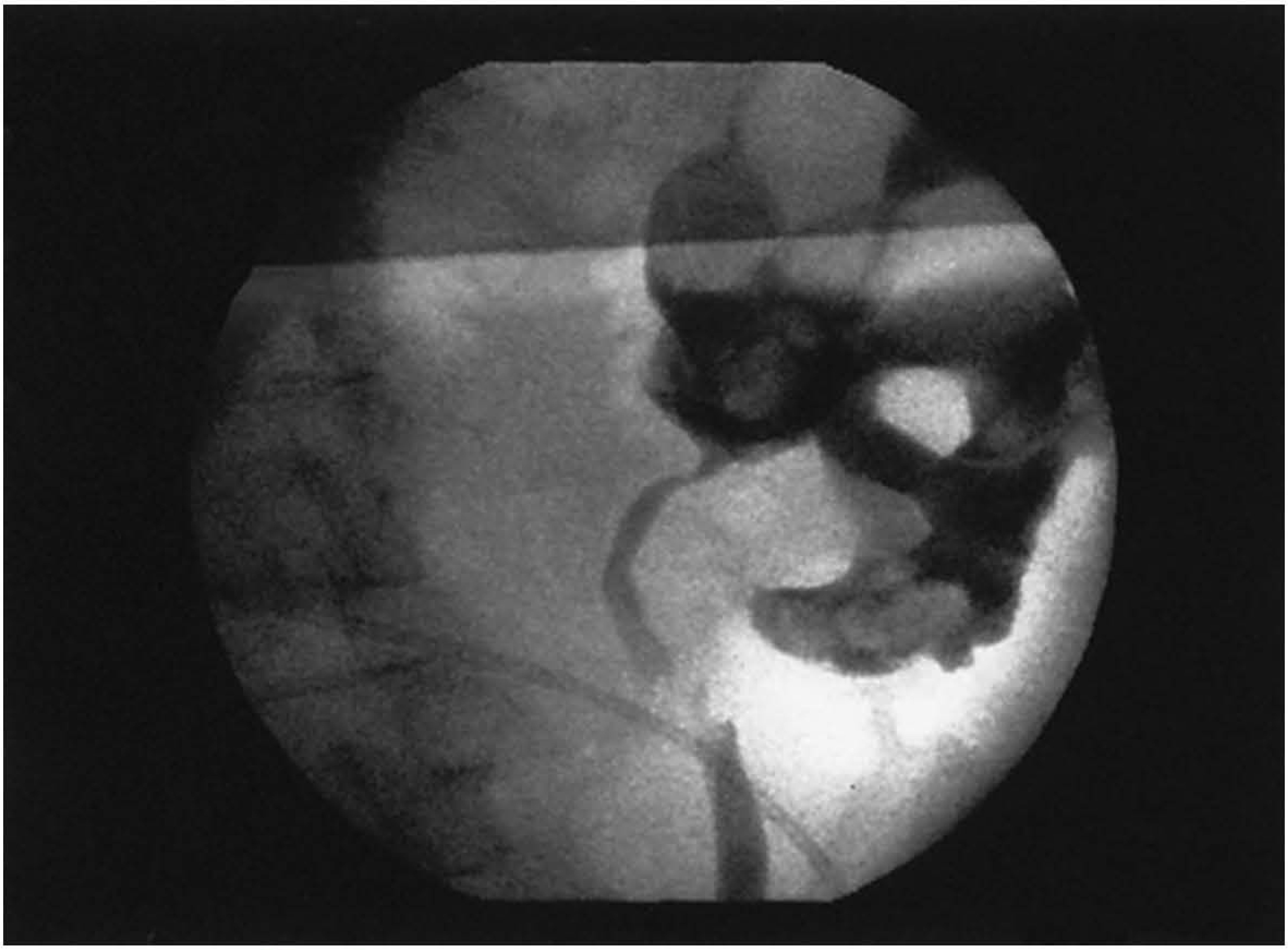

Figure 8.7 **Left pyelocaliceal filling defect (retrograde pyelogram).**

Antegrade pyelography is not recommended in patients with suspicion of TCC because of the risk of secondary tumor seeding along the percutaneous tract.

Ultrasonography can detect kidney stones, being useful for the differential diagnosis of filling defects visualized on urography, but its accuracy is reduced regarding the detection of tumors developed in the upper urinary tract.

Computed tomography (CT) is used especially for the differential diagnosis of a filling defect discovered on urography. This method can differentiate a radiolucent stone (80–250 Hounsfield units – HU) from tumoral tissue (10–70 HU) (Fig. 8.8).

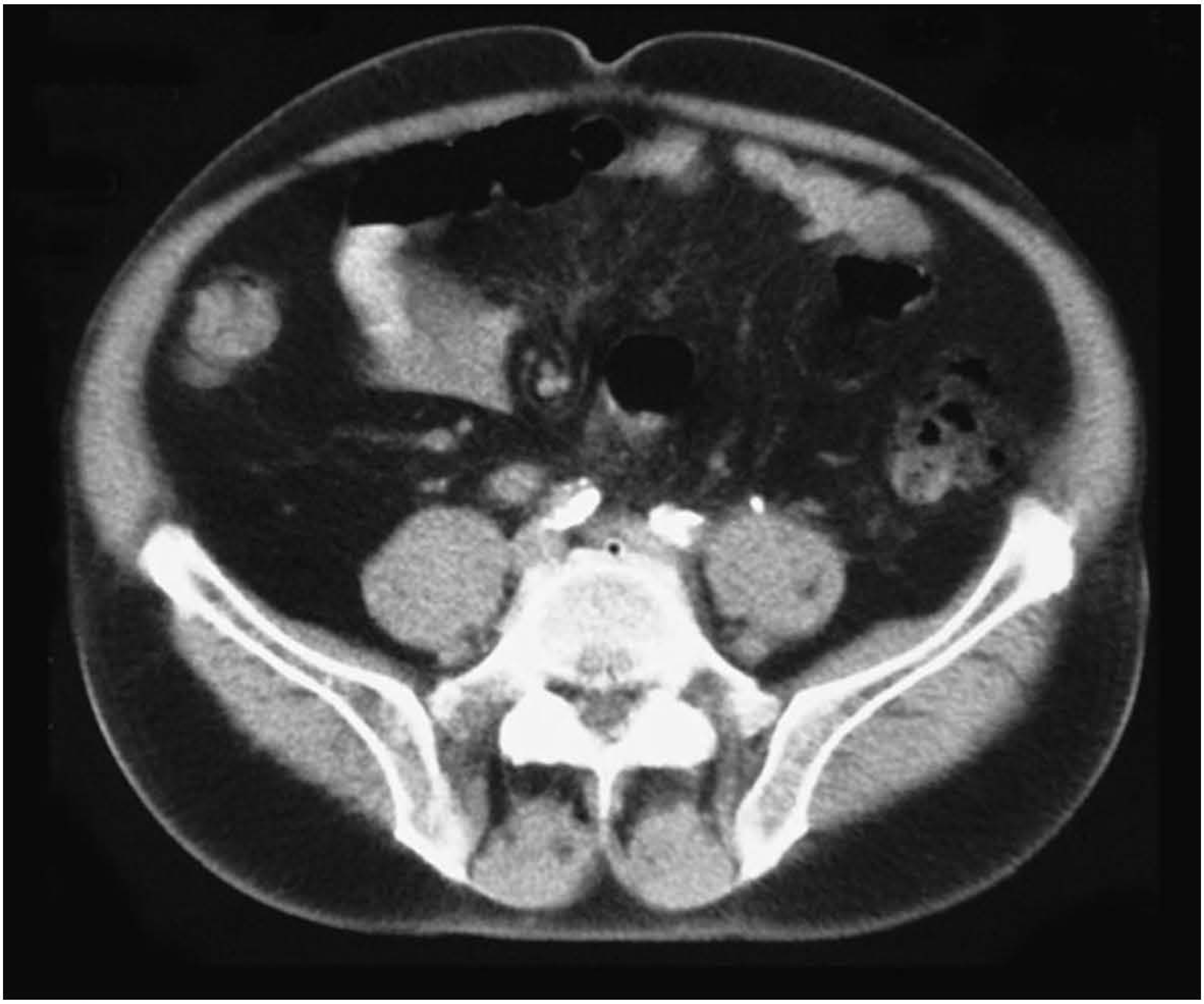

Figure 8.8 **Right ureteral tumor detected on computed tomography in a patient with total hematuria.**

The sensitivity of CT is approximately 90%, but it cannot differentiate between a T1 and a T2 tumor. The percentage of false-negative results regarding the assessment of local tumoral invasion is 59%. Still, the CT exam is very useful for identifying the locoregional extension (Fig. 8.9) or lymph node masses (McCoy et al., 1991).

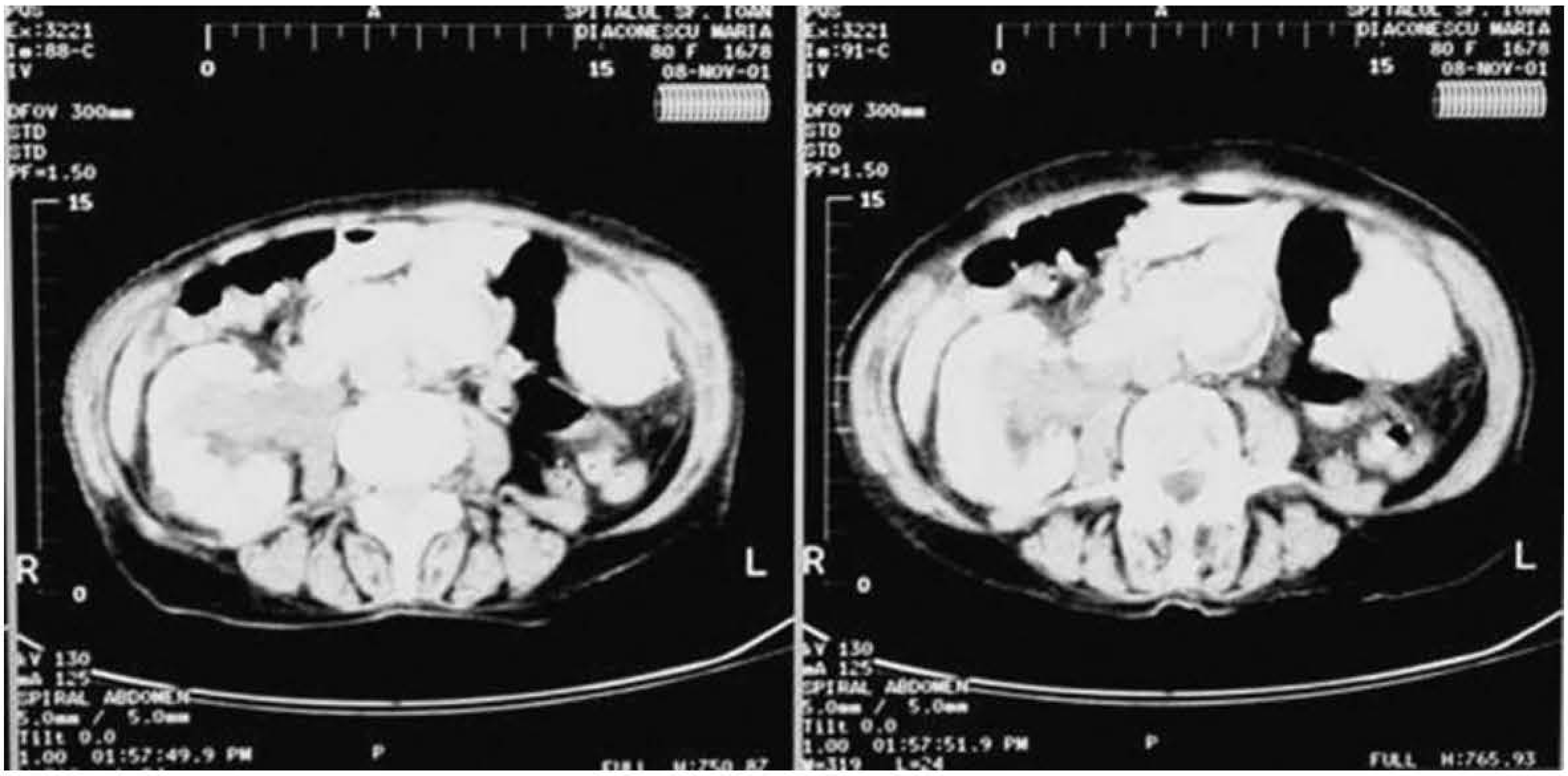
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Figure 8.9 **Right pyelocaliceal tumor with perihilar adenopathy (CT aspect).**

Nuclear magnetic resonance shows similar results to the CT exam regarding the diagnosis of TCC (Milestone et al., 1990), proving to be useful in certain patients with nonfunctioning kidneys or with severe allergies to contrast agents.

8.2.2. Urinary Cytology

Urinary cytology has a limited role in the diagnosis of TCC due to the increased frequency of false-positive and false-negative results (Fig. 8.10). There is a direct correlation between the cytological exam's sensitivity and the TCC grade (Fig. 8.11). The sensitivity ranges from 10% for grade 1 lesions to 80% for grade 4 lesions, with a specificity of approximately 60% (Messing, 2002) (Fig. 8.12). According to some authors, urinary cytology may be useful for the diagnosis of CIS, with an accuracy of approximately 80% (Dodd et al., 1997). However, urinary cytology for low-grade TCC can have false-negative results in 96% of cases (Messing, 2002).

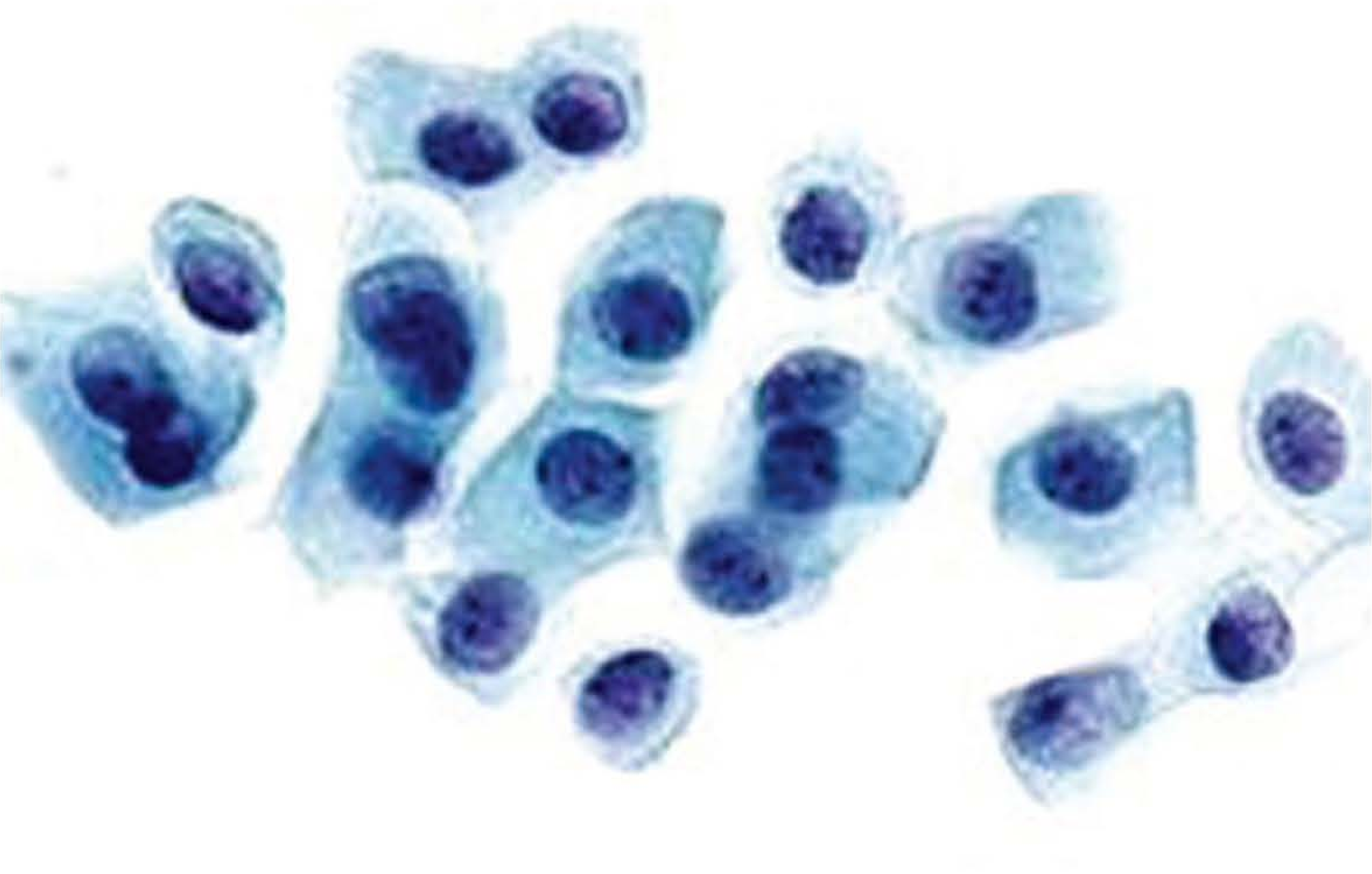

Figure 8.10 **Negative cytology in a patient with T1 ureteral tumor (false-negative result).**

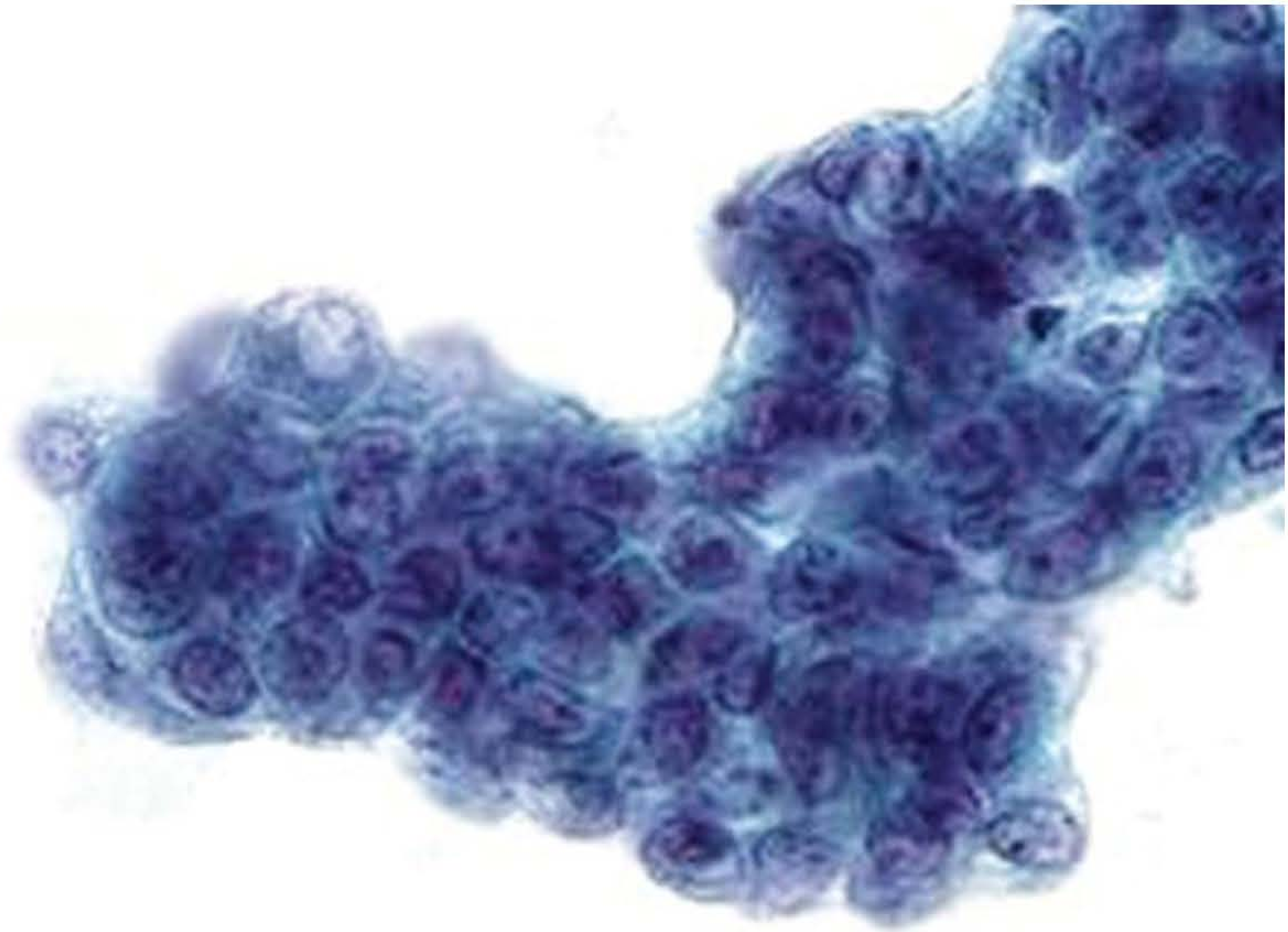

Figure 8.11 Urinary cytology – moderate atypia which cannot exclude a neoplastic lesion (patient with a pT2G3 renal pelvis tumor).

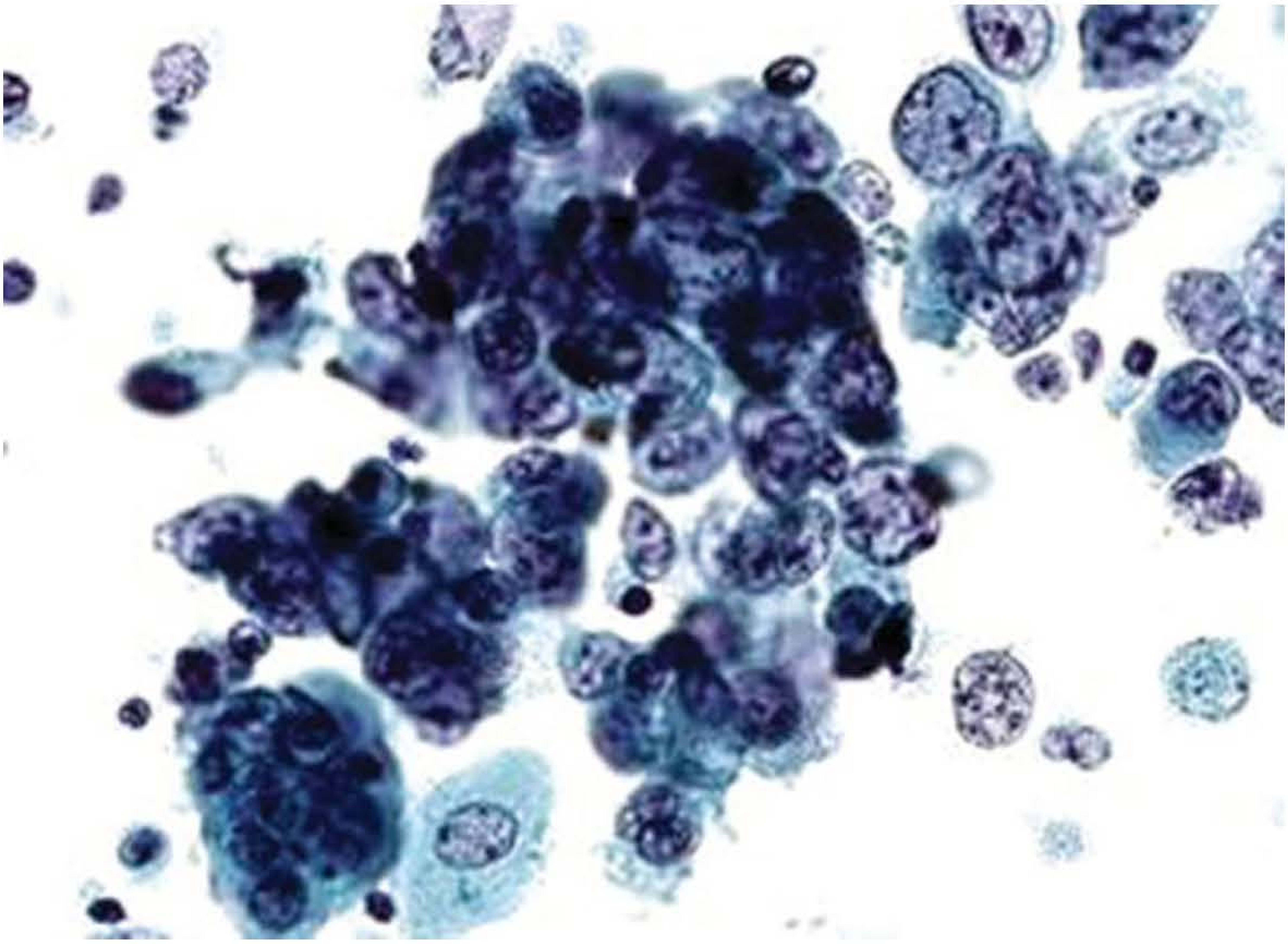

Figure 8.12 **Positive cytology with severe atypia (patient with pT3G3 ureteral tumor).**

The use of molecular biology techniques (p53 protein immunophoresis, flow cytometry for DNA ploidy analysis) can determine an increase in the sensitivity of the diagnosis of low-grade TCC (Oldbring et al., 1989; Keeley, 1997b).

Selective urinary cytology obtained by ureteral catheterization (although disputed by some authors who prefer to perform a diagnostic ureteroscopy) can increase the diagnostic accuracy, having a 65–78% sensitivity (Sadek et al., 1999). The exam is indicated in patients with positive cytology, without significant radiographic changes and with normal cystoscopy and bladder biopsy. The urinary cytological examination obtained by sparging with saline solution (after ureteral catheterization) has a superior diagnostic accuracy compared to simple cytology (Leistenschneider and Nagel, 1980).

Many authors (Gill et al., 1973; Blute et al., 1981; Sheline et al., 1989) have demonstrated the superiority of filling defects biopsy by fluoroscopically guided brushing (brush biopsy). The technique is performed by successive movements of the biopsy brush on the filling defect that was detected fluoroscopically after the introduction of 1/2–1/3 diluted contrast agent. The sensitivity and specificity of the method ranges between 72–91% and 88–94%, respectively (Gittes, 1980; Dodd et al., 1997). To avoid false-positive results due to contamination, potential bladder tumors should be treated before performing the procedure. However, this technique is not recommended if performing a diagnostic ureteroscopy is intended.

8.2.3. Endoscopic Diagnosis

The endoscopic evaluation of a patient with suspected TCC includes the examination of both the entire bladder and of the upper urinary tract.

Cystoscopy is an essential step in the assessment of a patient with hematuria and/or filling defects detected radiologically, due to the high risk of the coexistence of associated bladder tumors. It also facilitates ureteral access in order to perform a retrograde pyelogram. The upper urinary tract is evaluated only after a complete inspection of the bladder and the biopsy of any suspicious lesions, by performing a retrograde ureteropyelogram, which offers more information regarding the filling defect (Fig. 8.13). It is indicated to use a probe with a conical tip through which the contrast agent is injected, thus efficiently visualizing the entire collecting system without secondary traumatic ureteral injuries.

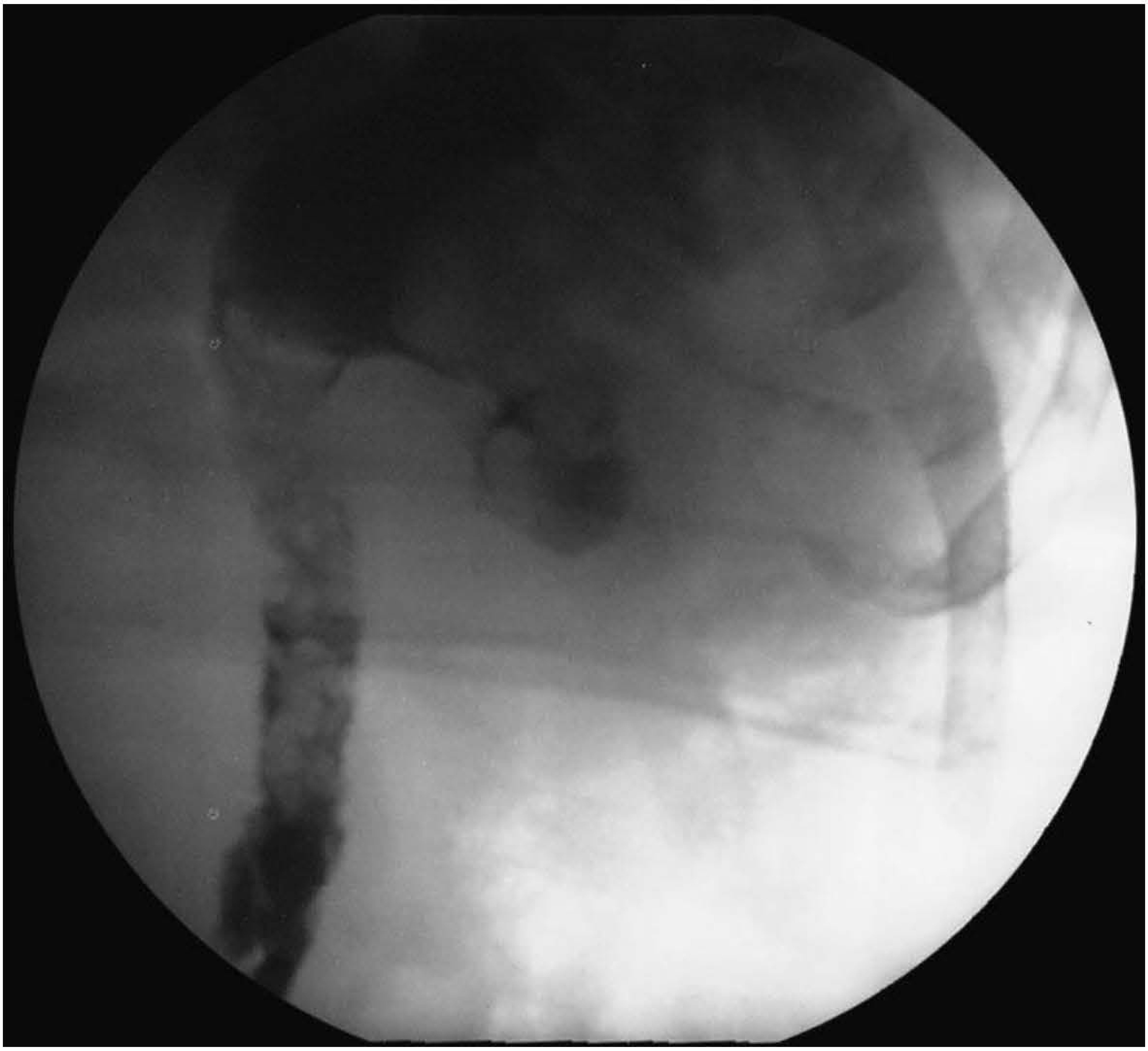

Figure 8.13 Filling defect of the right lumbar ureter (multiple ureteral tumor).

Sometimes, in order to define the lesion's extension as exactly as possible, multiple injections of contrast agent with different concentrations are necessary. However, overfilling of the pyelocaliceal system and the use of an excessively concentrated contrast agent should be avoided because these can create a too-intense opacification and may hide potential filling defects.

Ureteroscopic assessment of filling defects of the upper urinary tract can improve the diagnostic accuracy (Figs 8.14 and 8.15). Moreover, besides the upper urinary tract's visualization, the method offers the opportunity to biopsy any suspicious lesions, allowing their histological exam. Thus, the tumor grade and sometimes even the tumor stage can be determined. Progress in terms of design, optics, dimensions, and the degree of deflection of flexible ureteroscopes allow the diagnosis of filling defects, in all cases, by direct inspection and tumor biopsy.

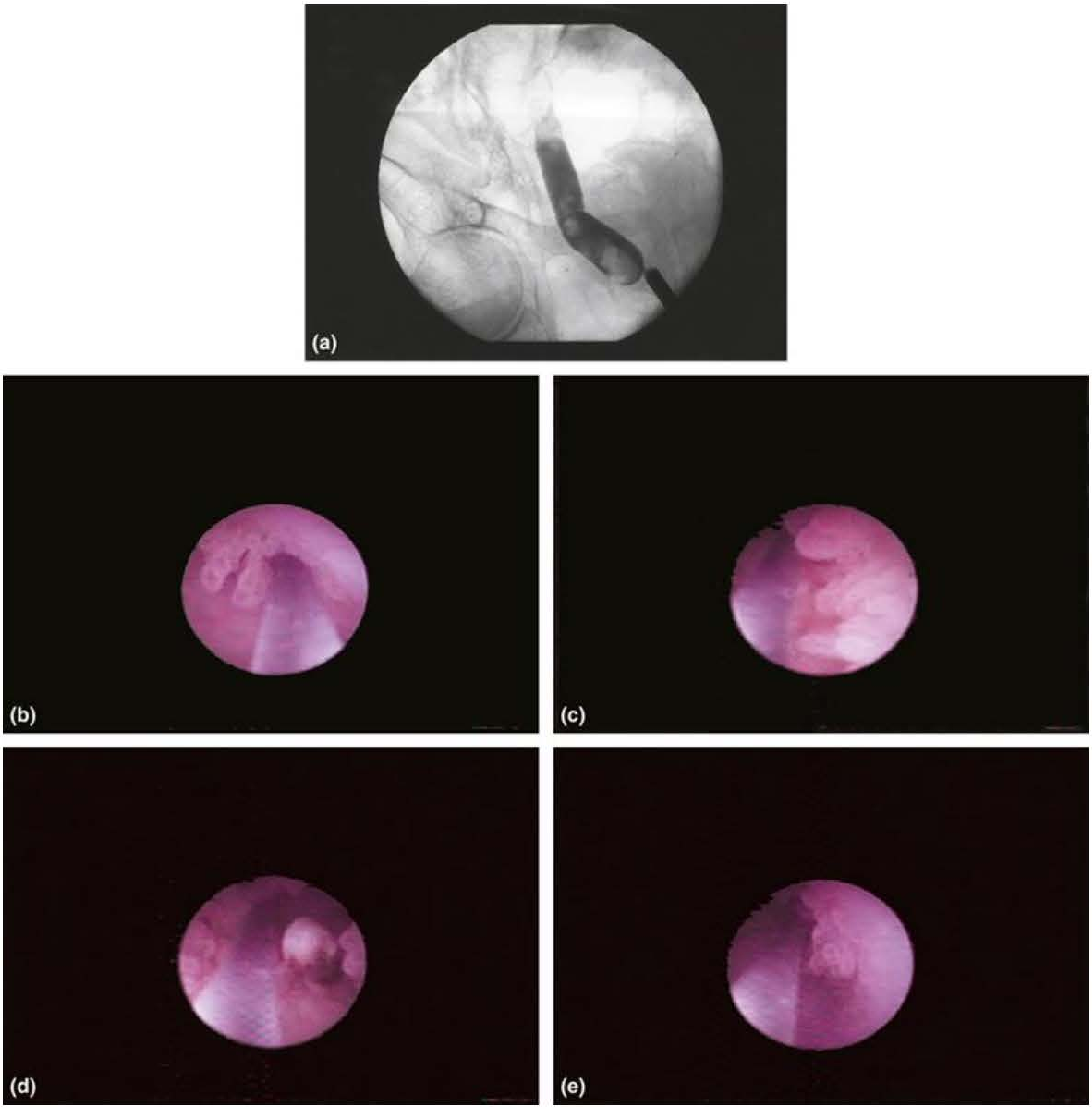

Figure 8.14 Radiological (a) and ureteroscopic (b–e) aspect of multiple pelvic ureteral tumors.

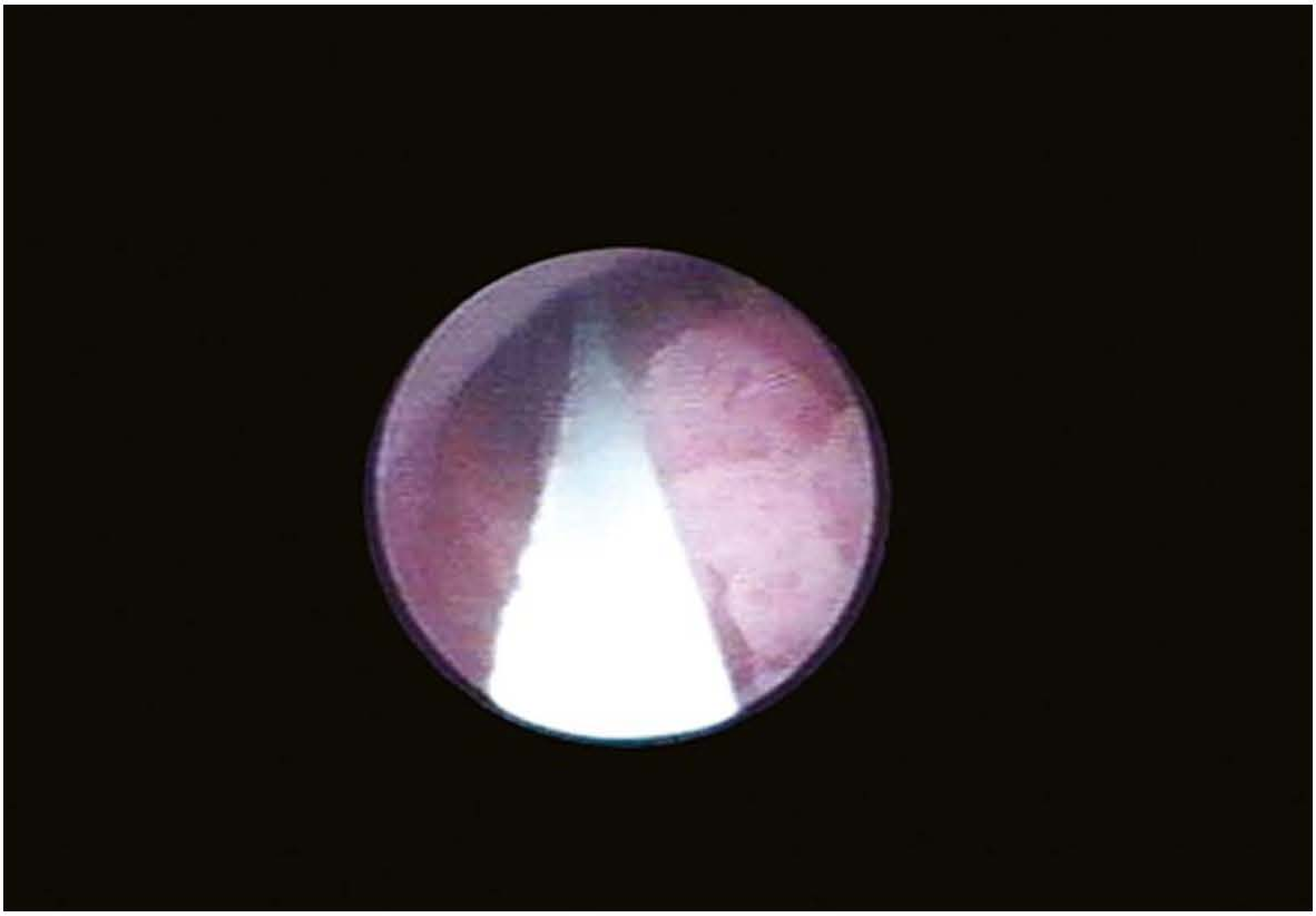

Figure 8.15 **Lumbar ureteral tumor (retrograde ureteroscopy).**

In patients with suspected TCC, most authors prefer the no-touch technique for examining the ureter and the pyelocaliceal system. It is recommended to initially insert a 6.9 F semirigid ureteroscope under direct visualization, the dilation of the ureteral orifice being achieved by increasing the pressure of the irrigation fluid. It is usually recommended to avoid using a reinforced metallic guidewire in order to prevent ureteral injuries that can mask a possible tumor (Streem et al., 1986).

The assessment using a semirigid ureteroscope can be limited to the distal third of the ureter (in certain cases) or it may also include the renal pelvis (when possible). The exploration is completed with the flexible ureteroscope (Fig. 8.16), which allows for the inspection of all the caliceal groups, using the technique described in the diagnosis chapter.

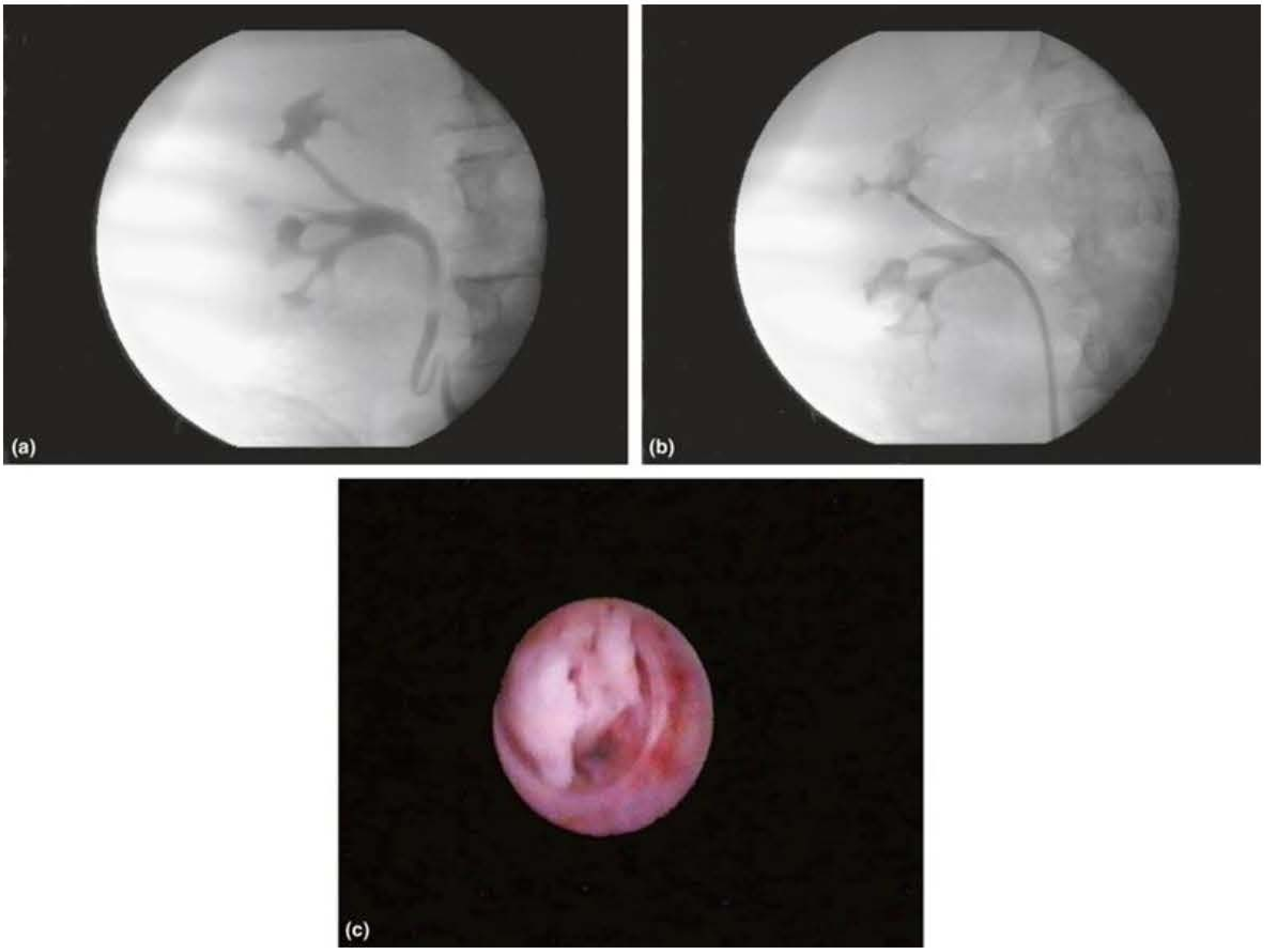

Figure 8.16 **Flexible ureteroscopy under fluoroscopic control (a, b) showing an upper caliceal tumor (c).**

In most cases, visual inspection can diagnose a filling defect that was previously detected radiologically (Kavoussi et al., 1989; Blute et al., 1989). Thus, a low-grade papillary tumor can be easily differentiated from a stone or from an extrinsic compression. Fluoroscopic control is absolutely necessary in order to demonstrate the positioning of the ureteroscope's tip at the level of the filling defect, thus confirming the correct identification of the lesion.

TCC can have completely different endoscopic aspects (Fig. 8.17). Low-grade transitional carcinomas can present typical papillary aspects, similar to those located in the bladder. Invasive transitional carcinomas can be more sessile and less papillary, often presenting areas of necrosis. Fibroepithelial polyps located in the renal pelvis and inverted papillomas generally have a soft round surface, giving the impression of an intact epithelial layer (Bagley et al., 1990) (Fig. 8.18). These aspects are not pathognomonic, and both fibroepithelial polyps and inverted papillomas located at the pyeloureteral junction can be elongated with a vermiform aspect.

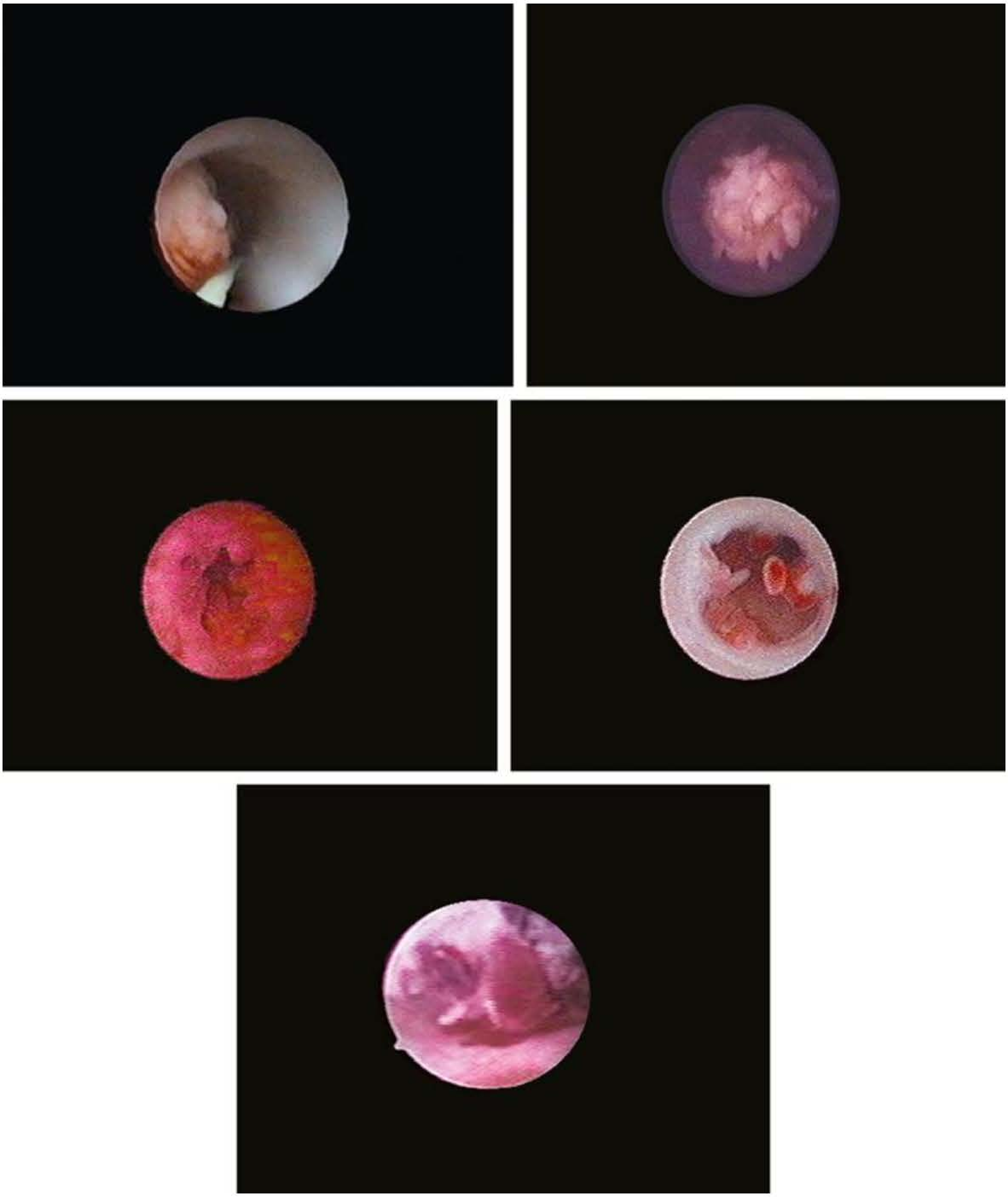

Figure 8.17 **Particular endoscopic aspects of TCC.**

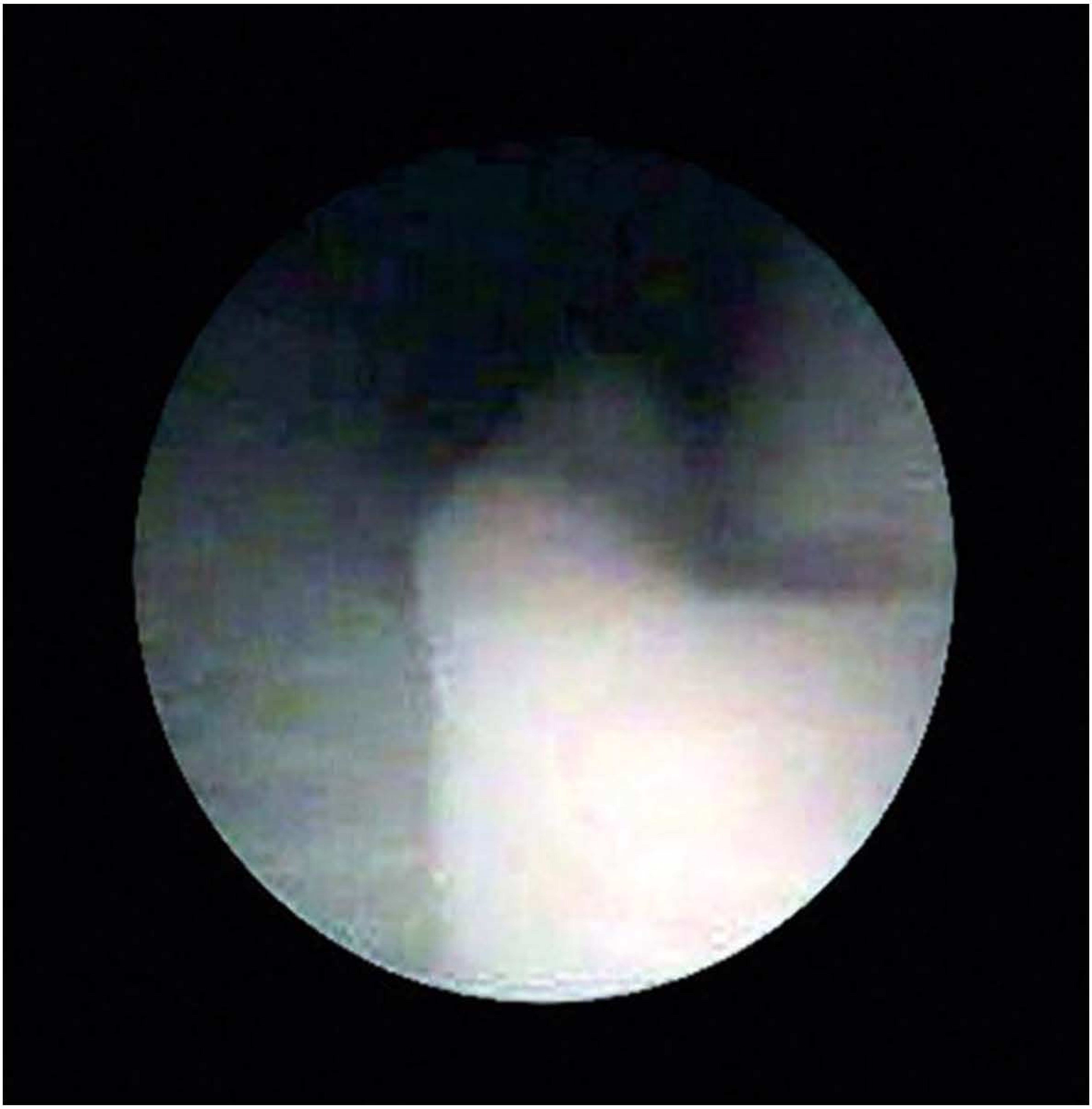

Figure 8.18 **Fibroepithelial ureteral polyp.**

In some cases, visual inspection cannot accurately determine the diagnosis of cancer. Thus, high-grade urothelial carcinomas can be mistaken for inflammatory lesions or can be difficult to visualize due to obstructive peritumoral edema.

Sometimes, the tumor can be mistaken for a stone due to the presence of calcifications on its surface. Other tumors, with a necrotic surface, can resemble a soft stone, with infectious etiology, covered by inflammatory detritus.

In these cases, as in many others, visual inspection alone is not enough for the diagnosis, other interventional endoscopic maneuvers being necessary in order to obtain a correct diagnosis.

A technology that improves the detection of malignant lesions is NBI (narrow band imaging), described in the section dedicated to bladder tumors (Fig. 8.19).

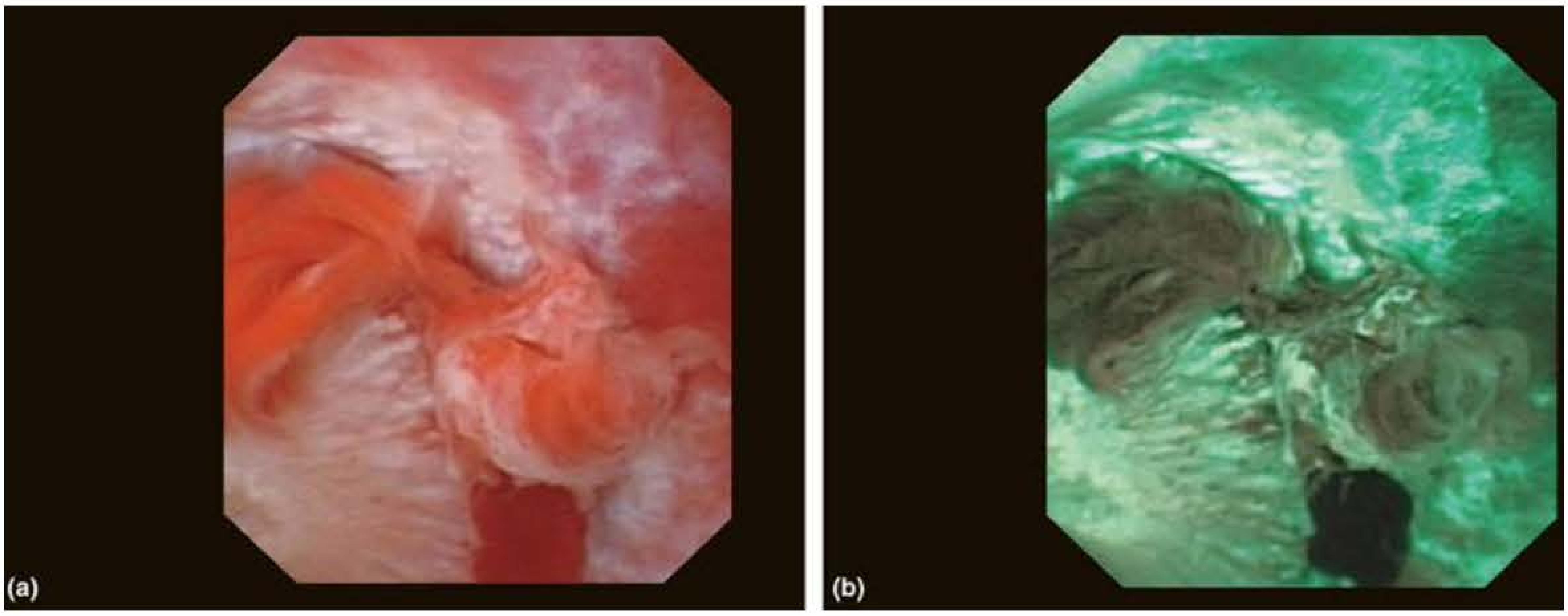

Figure 8.19 **Caliceal tumor mass visualized in white light (a) and NBI (b).**

8.2.4. Tumor Biopsy

Ureteroscopic biopsy is important for obtaining neoplastic tissue specimens, thus providing the possibility to establish the histological diagnosis. It is a valuable process, not only for determining the malignant nature of the disease, but also for assessing the grade of a transitional carcinoma. The reduced dimensions of the ureteroscope's working channel limits the insertion of accessory instruments in order to achieve an adequate biopsy.

There are several ways to perform a tumor biopsy. The diagnostic accuracy can be increased by using forceps or basket catheters for biopsy. The main problem of biopsy forceps is the reduced dimensions of the fragment obtained, which can be insufficient for the histological diagnosis.

For example, the tissue fragment obtained with a 3 F biopsy forceps is less than 1 mm in diameter and is usually too small to be prepared for the histological exam using standard techniques. Still, the collected tissue sample is more than enough for the cytological exam. It can be prepared as a cell block, stained and examined as a histological sample, in order to establish a diagnosis and to provide information on the cellular grading.

Some authors have used Piranha forceps (Boston Scientific, Natick, MA) to collect fragments with a reasonable size (Figs 8.20 and 8.21).

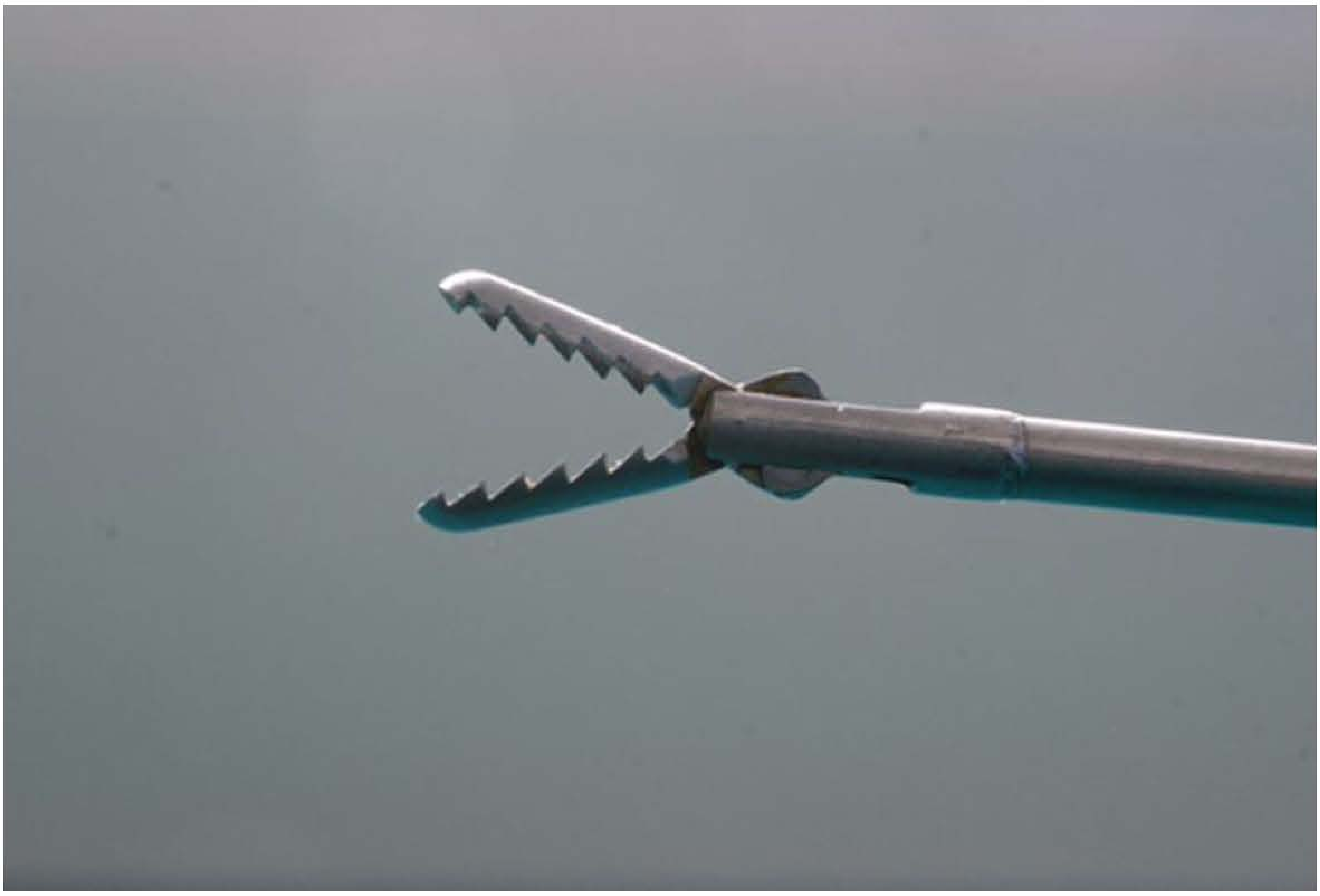

Figure 8.20 **Biopsy forceps.**

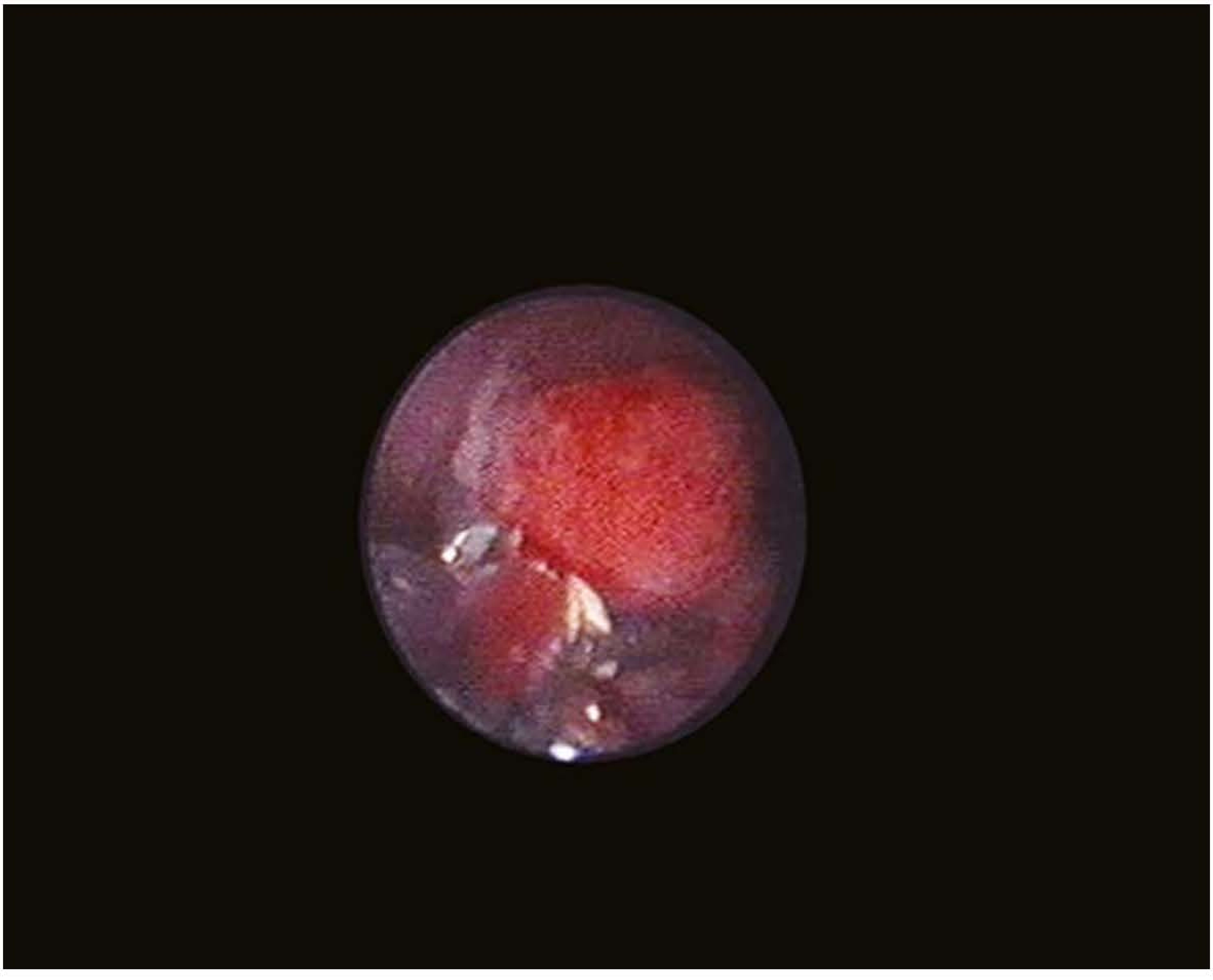

Figure 8.21 **Forceps biopsy of a ureteral tumor.**

Even more useful are the basket catheters (Figs 8.22 and 8.23) that are positioned at the level of the lesion, are closed partially under direct visual control, and are then withdrawn en bloc, together with the ureteroscope. Tissue fragments with adequate dimensions (up to 1 cm) can be obtained in this way for histological and cytological exam.

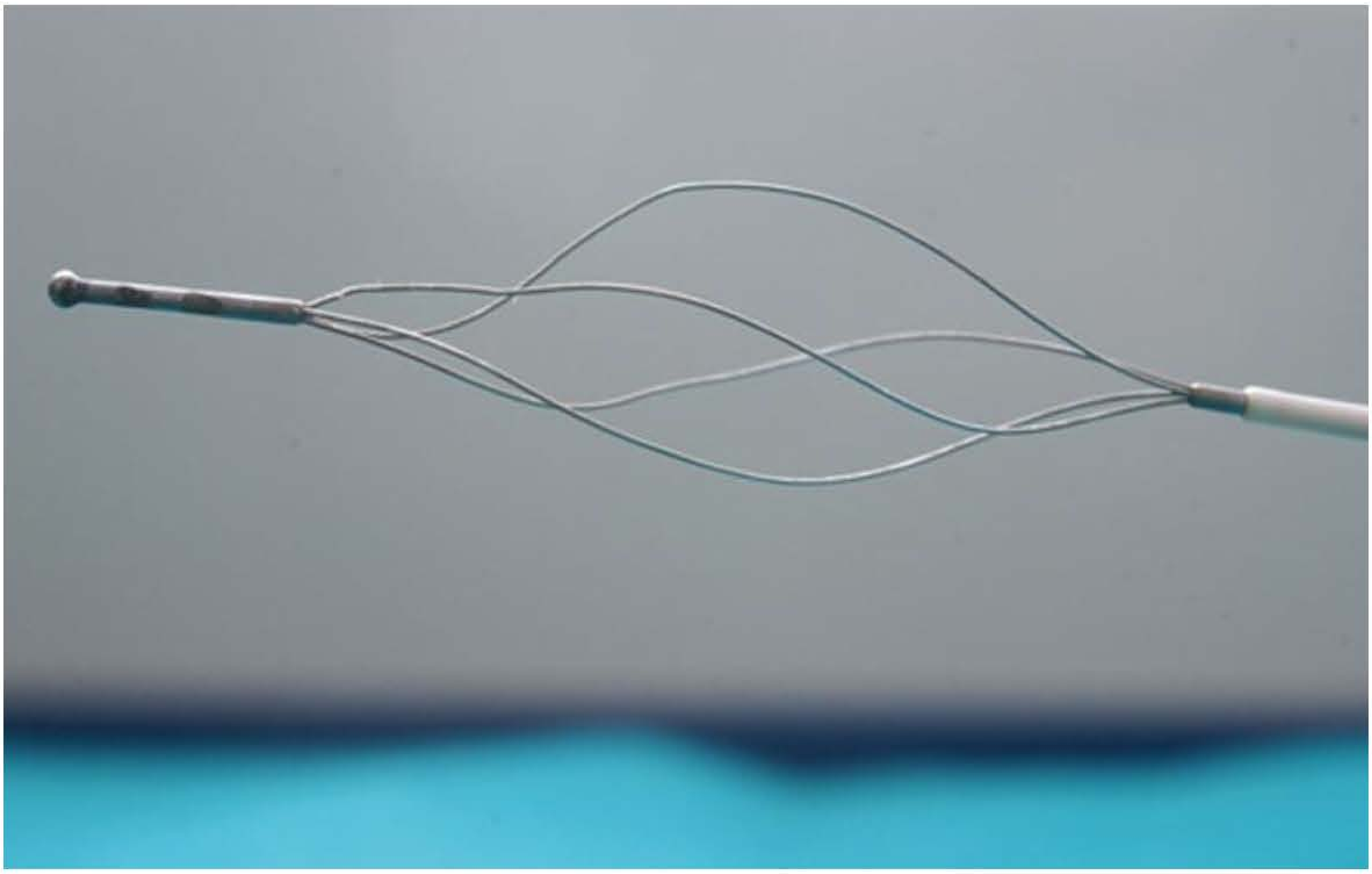

Figure 8.22 **Basket catheter for tumor biopsy.**

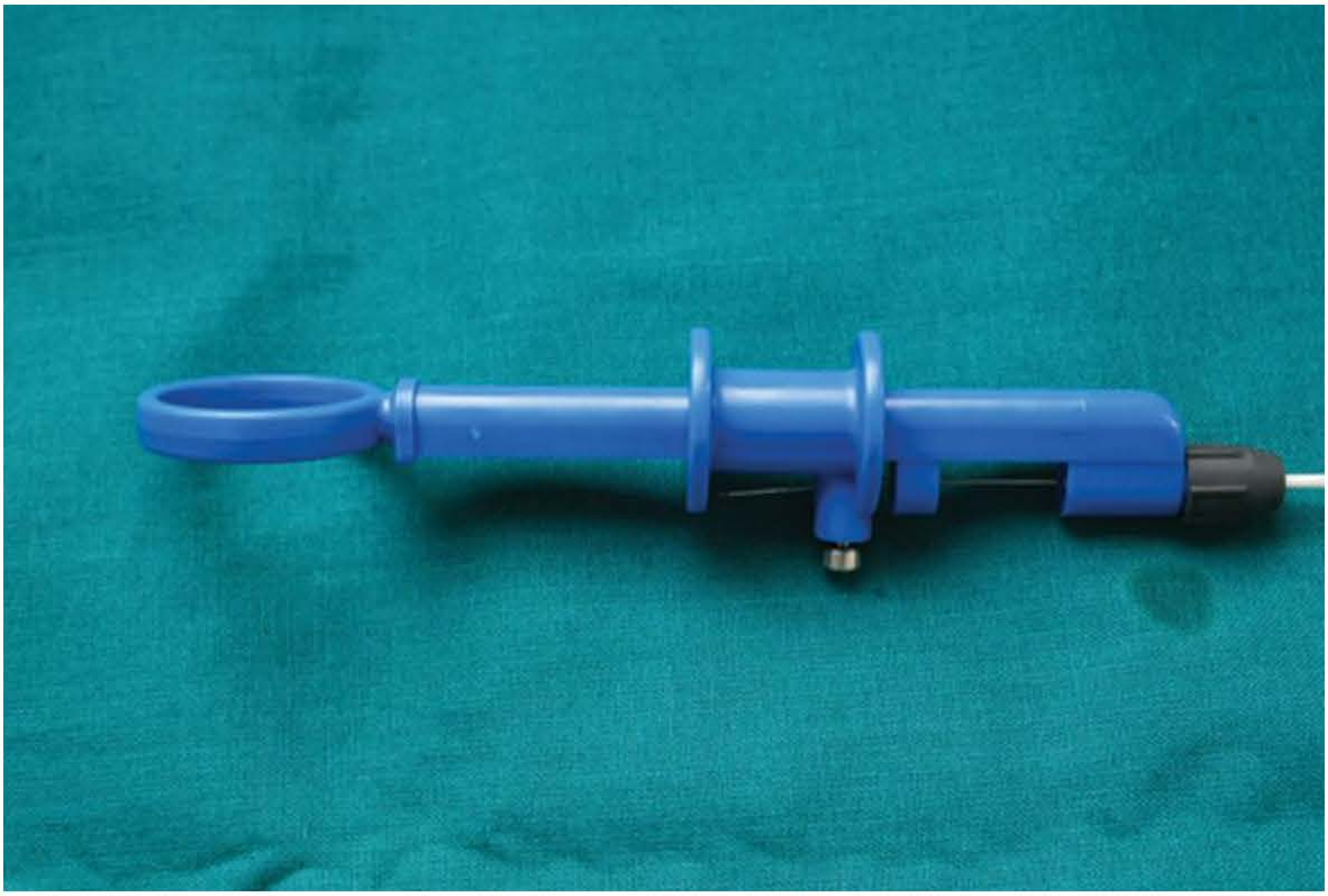

Figure 8.23 **Device used for handling the basket catheter.**

The tissue obtained is introduced into a container with formaldehyde and sent for histological examination. If the dimensions of the tissue are smaller than 1 cm, it is placed in saline solution and sent for cytological exam.

One of the most important factors regarding the accuracy of the histological diagnosis is represented by the close cooperation with the pathologist (Bagley et al., 1994).

The specificity of the ureteroscopic biopsy regarding the correct diagnosis of TCC varies between 75% and 92% (Keeley, 1997c). When the biopsy cannot be performed under direct visual control, the basket is positioned at the level of the lesion (filling defect) under fluoroscopic control.

A Segura-type basket is usually recommended for friable tumors, while Piranha-type forceps are more commonly used for sessile lesions. Some authors also recommend tumor brushing, especially for flat or sessile lesions, although this procedure is less sensitive in terms of diagnostic accuracy because it fails to collect big enough tissue fragments (Abdel-Razzak et al., 1994).

The contralateral renal unit should be assessed before starting treatment for the primary lesion. This is achieved by selective ureteral cytology, intravenous urography, and retrograde pyelography. In case of a suspected contralateral lesion, a flexible ureteroscopy can be performed.

8.2.5. Staging

The correct preoperative staging allows the appropriate selection of cases and the optimal choice of treatment. The presence of metastases or the massive invasion of the renal parenchyma represent important preoperative factors, regardless of the therapeutic method.

CT scan can be useful for determining the local extension, especially to assess the invasion of the renal parenchyma, of regional lymph nodes, of the periureteral tissue, of the renal veins, or of the adjacent structures (Fig. 8.24). This method can also identify hepatic metastases. However, the CT exam cannot differentiate between T1 tumors on the one hand and small T2 or T3 tumors on the other. Also, the sensitivity for identifying multiple tumors is reduced (Messing, 2002).

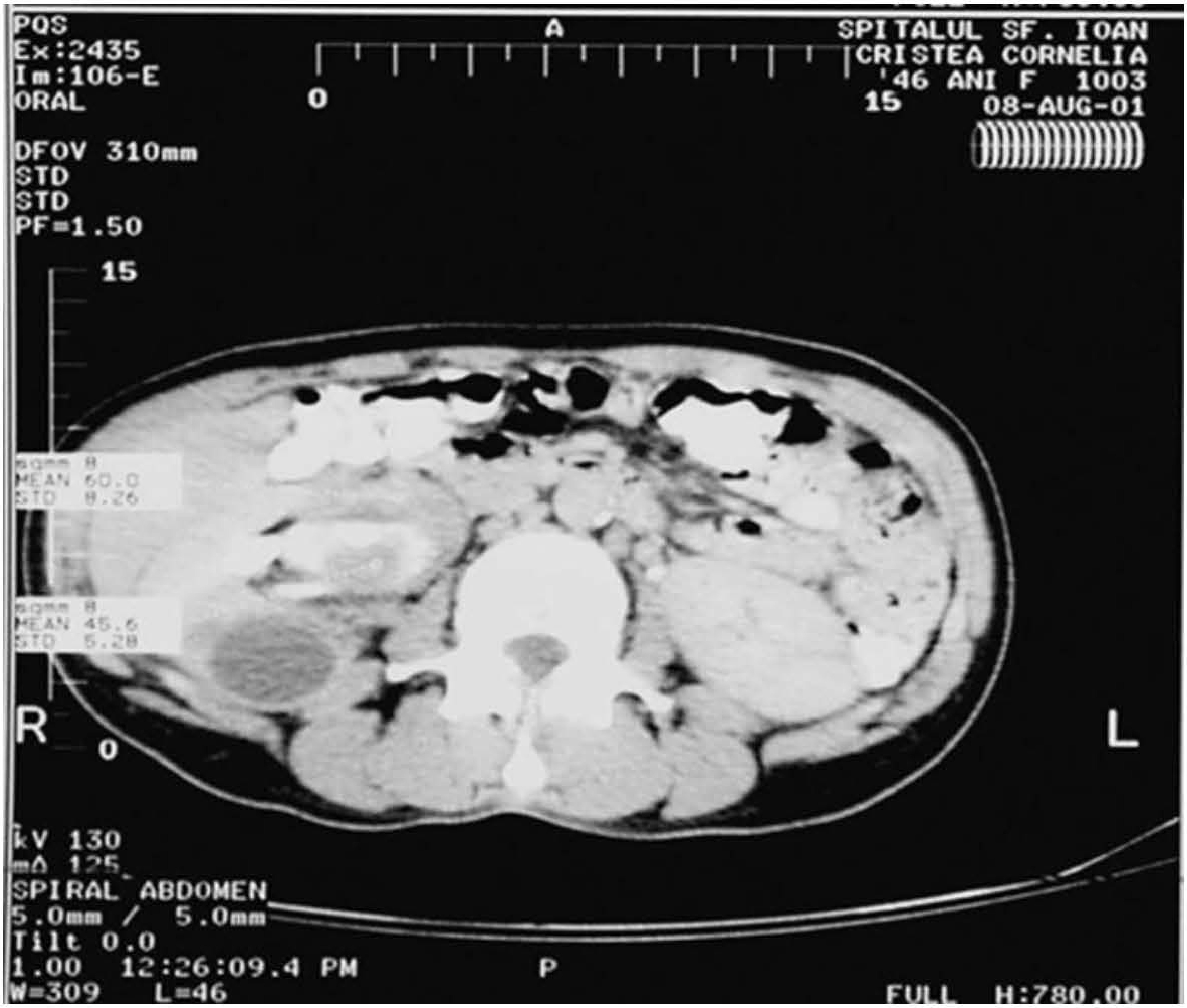
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Figure 8.24 **Renal pelvis tumor with renal parenchyma invasion (CT aspect).**

Endoluminal ultrasonography has been described as a promising technique for staging ureteral tumors (Bagley et al., 1992). Probes with frequencies between 12.5 MHz and 40 MHz can be used, characterized by a low tissue penetration and a high resolution (Fig. 8.25).

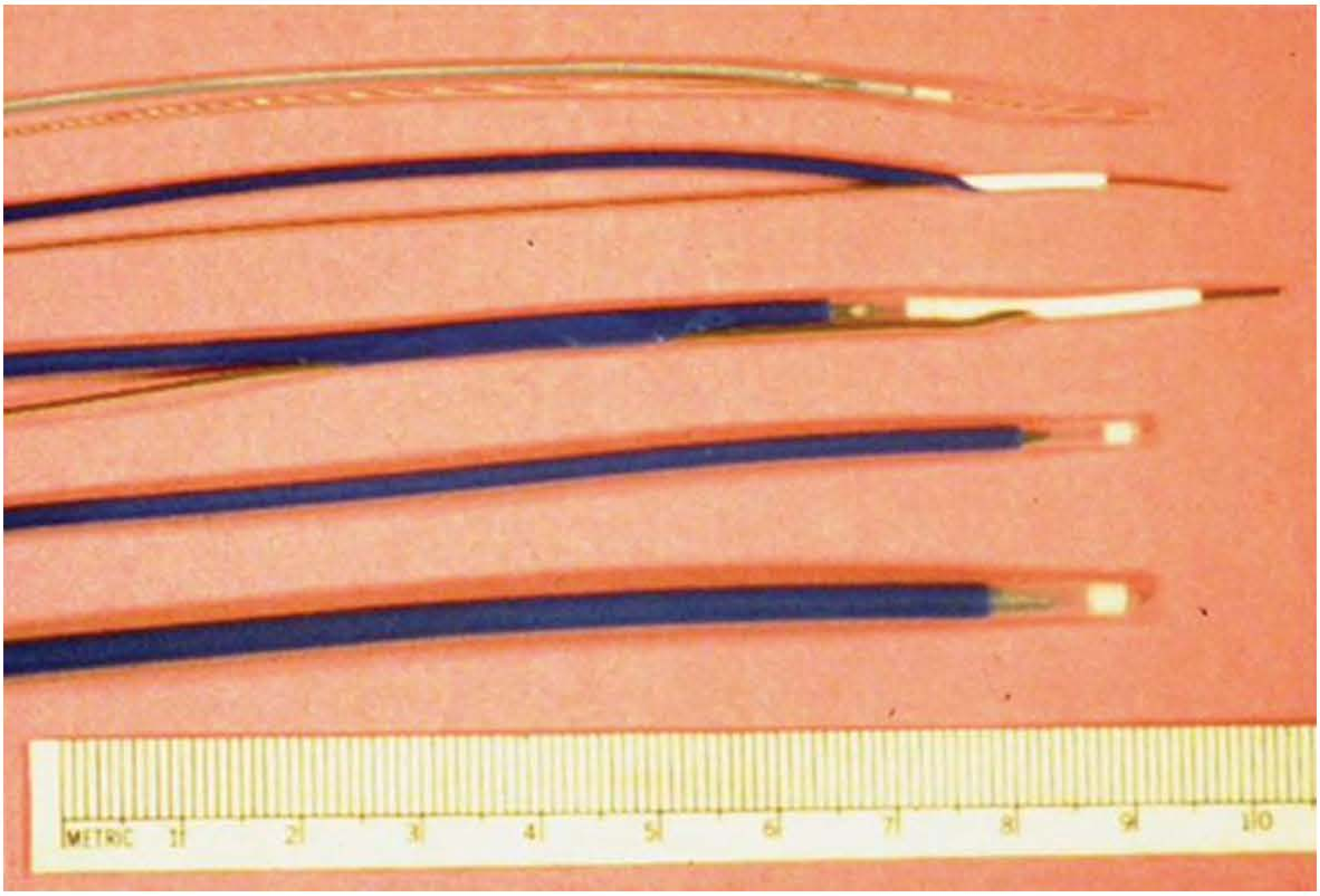

Figure 8.25 **Probes for endoluminal ultrasonography.**

The most commonly used are the 3.5–6.2 F probes (Boston Scientific, Natick, MA; Olympus America Inc, NY). These can be inserted into the ureter through a cystoscope or even directly through the ureteroscope.

The maximum resolution of the 20 MHz probes is up to 1.5–2 cm, a distance long enough to visualize the ureteral wall and the periureteral pathological changes (Grasso et al., 1999) (Figs 8.26 and 8.27). The results of the studies published in the literature show a good correlation between the staging achieved by endoluminal ultrasonography and the histological (final) stage (Liu et al., 1997; Liu, 2006). However, the experience is limited, the technique being conditioned by the availability of instruments.

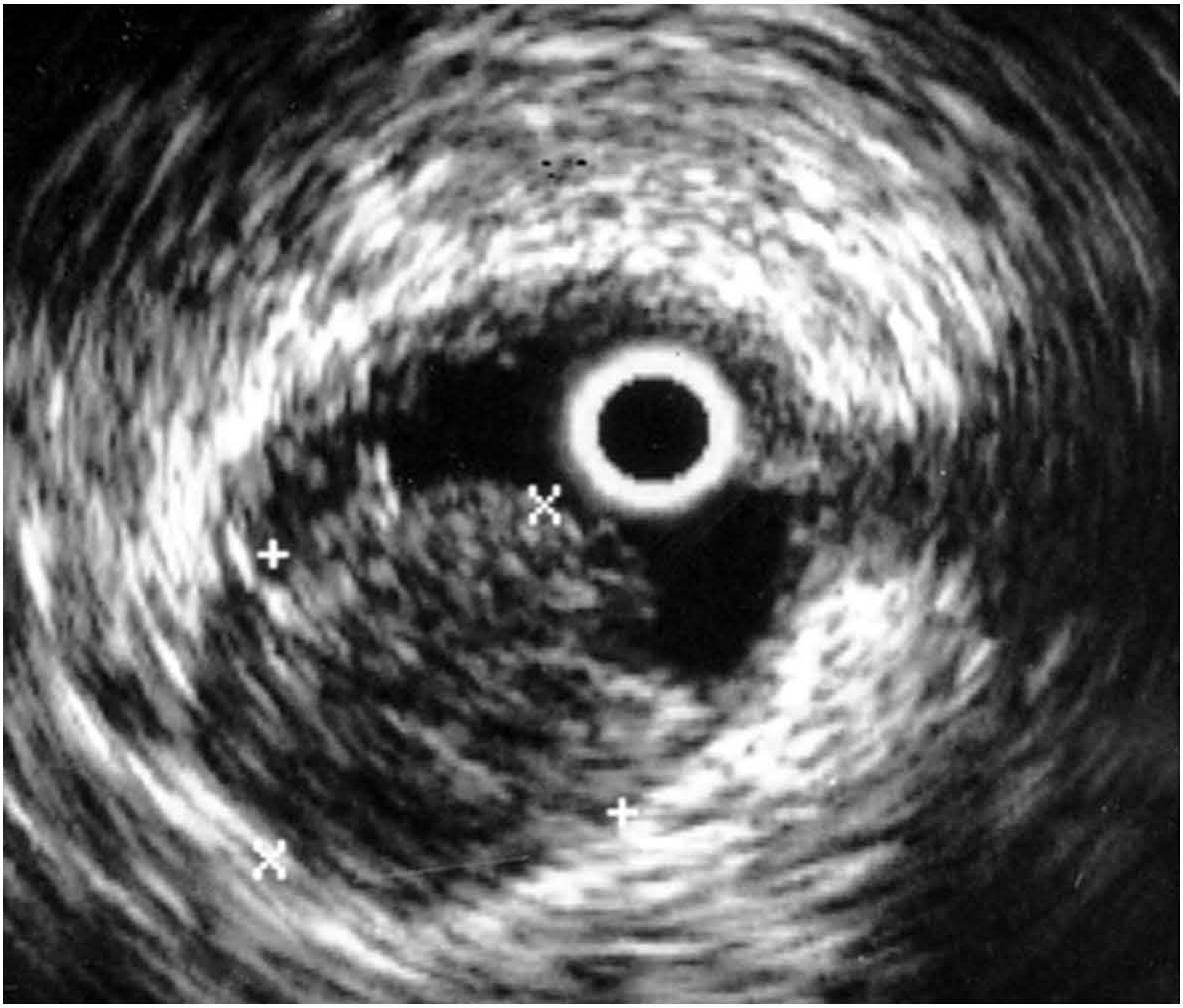

Figure 8.26 **Endoluminal ultrasonography – ureteral tumor.** Source: With permission from Liu (2006).

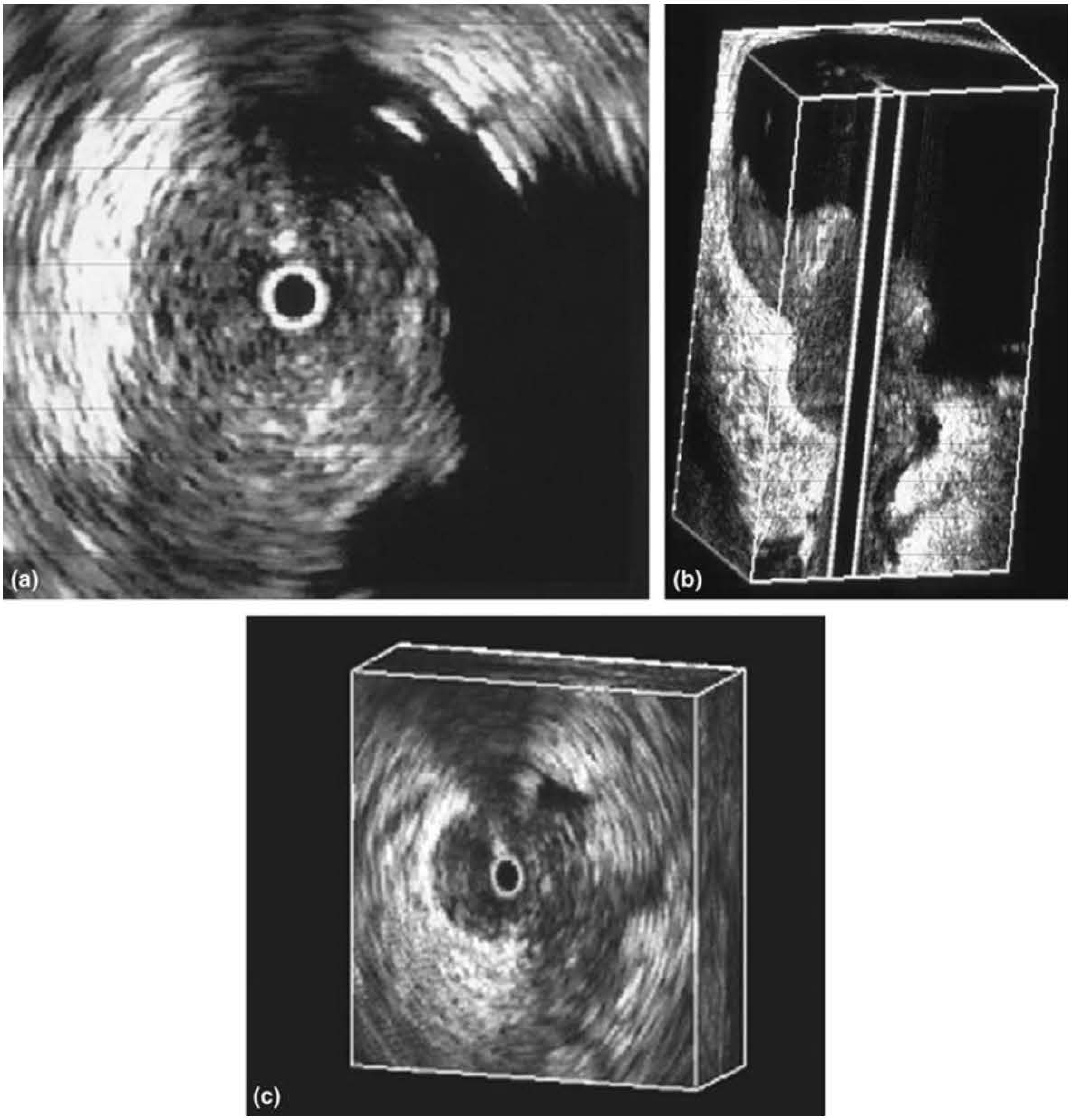

Figure 8.27 **Tumor located at the uretero-pelvic junction: 2D (a), respectively 3D (b, c) endoluminal ultrasonography.** Source: With permission from Liu (2006).

Regarding the ureteroscopic biopsy of TCC, some authors have suggested that this can lead to local or systemic dissemination of tumor cells by pyelo-venous or pyelo-lymphatic reflux (Lim et al., 1993). However, this mechanism has only been demonstrated in one case, most authors underlining that tumor biopsy does not modify the prognosis or the survival rate of patients with TCC (Kulp and Bagley, 1994; Hendin et al., 1999; Hara et al., 2001).

8.3. Indications

The therapeutic alternatives for TCC are represented by:

- nephroureterectomy with open surgical perimeatic cystectomy
- nephroureterectomy with endoscopic perimeatic cystectomy
- laparoscopic nephroureterectomy
- partial nephrectomy
- segmental ureteral resection
- ureteroscopic treatment
- percutaneous treatment

Nephroureterectomy with perimeatic cystectomy is considered the gold-standard treatment for large (Fig. 8.28), invasive, multifocal tumors or for recurrences after conservative treatment.

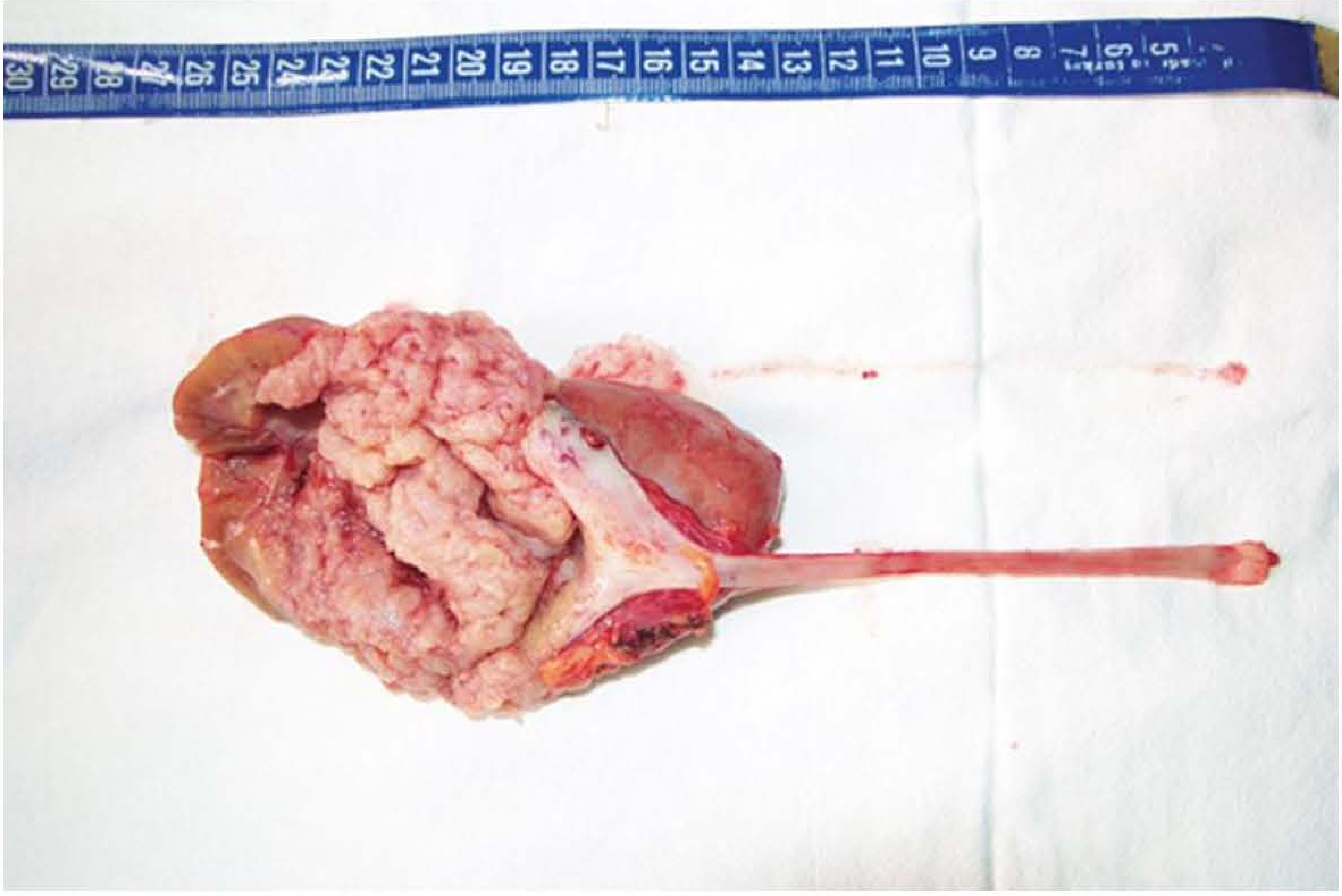

Figure 8.28 **Voluminous pyelocaliceal tumor (nephroureterectomy specimen).**

The main indications for the endoscopic treatment of TCC are represented by renal insufficiency, single kidney, bilateral tumors, comorbidities that contraindicate open surgery, and the patient's preference (Table 8.1).

Table 8.1

Indications for the Endoscopic Treatment of TCC

Indications	Controversial indications	Contraindications
• Single kidney • Renal insufficiency • Bilateral tumors • Comorbidities • Superficial tumors (Ta/1) • Low grade (G1–2) • Dimensions under 1.5–2 cm • Solitary tumors • Patient availability for	• Normal contralateral kidney • G2 tumor	• Unresectable tumor • High-grade tumor • Invasive tumor • Noncompliant patient Immediate nephroureterectomy will be performed in these situations

long-term follow-up		

Practically, there are two situations (Geavlete, 2003a,c):

- patients with a single kidney, compromised renal function or bilateral tumors
- patients with normal contralateral kidney

For the first situation, the indications for the endourological approach of a TCC are represented by:

- single, superficial tumor (Ta – T1)
- small tumor (1.5–2 cm)
- low-grade tumor (G1–2)

For patients with normal contralateral kidney, conservative endourological treatment is recommended for small solitary tumors (0.5 cm for ureteral tumors, 1 cm for pyelocaliceal tumors), with a low grade (G1), without associated CIS lesions.

The alternatives for endoscopic approach are represented by retrograde ureteroscopy or percutaneous approach (Table 8.2). The decision depends on the lesion's dimensions, location, and whether it is multifocal. Small accessible lesions, smaller than 1 cm, are more suitable for ureteroscopic treatment because it maintains the integrity of the urinary system. Large lesions or lesions that are difficult to access, located in the calyces, which cannot be approached ureteroscopically, have an indication for percutaneous approach. Although some authors have described cases of tumor recurrence on the nephrostomy tract, this has a low incidence.

Table 8.2

Comparison of Retrograde and Antegrade Approach of TCC

	Advantages	**Disadvantages**
Ureteroscopic	Low morbidity Reduced invasiveness Short hospitalization Maintenance of the integrity of the urinary system	Reduced visibility Small working channel It cannot be applied for large tumors Difficult approach for lower caliceal tumors Tumor specimens of limited size Difficult in case of urinary derivations
Percutaneous	Larger tumors, located in the lower caliceal group, can be treated Possible in case of urinary derivations High-caliber instruments Tract for adjuvant therapy Tract for a "second look"	High morbidity Longer hospitalization Risk of secondary seeding
Combined	Multifocal tumors	

8.4. Operatory technique particularities

Choosing the dimensions of the instruments, the devices used to destroy the tumor tissue, and the optimal approach should be individualized according to the particularity of each case and to the technical possibilities that exist or the surgeon's experience (Table 8.3).

Table 8.3

The Instruments Necessary for the Retrograde Approach of TCC

Cystoscope	Bladder inspection Retrograde ureteropyelogram
Fluoroscope	Intraoperative monitoring Ureteral stent placement
Ureteroscope	Rigid ureteroresectoscope Semirigid Flexibile (<6.9 F)
Energy sources	Electrosurgery source Ho:YAG Nd:YAG
Accessory instruments	Guidewires, fulguration electrodes, etc.

Removal of the tumor tissue can be achieved in several ways:

- mechanically
- by electroresection
- by fulguration
- by laser vaporization

Mechanical removal of the tumor tissue, reserved for cases with small pediculated tumors (Fig. 8.29), can be achieved using a basket catheter or a forceps. Subsequently, coagulation of the tumor base can be performed using a laser fiber.

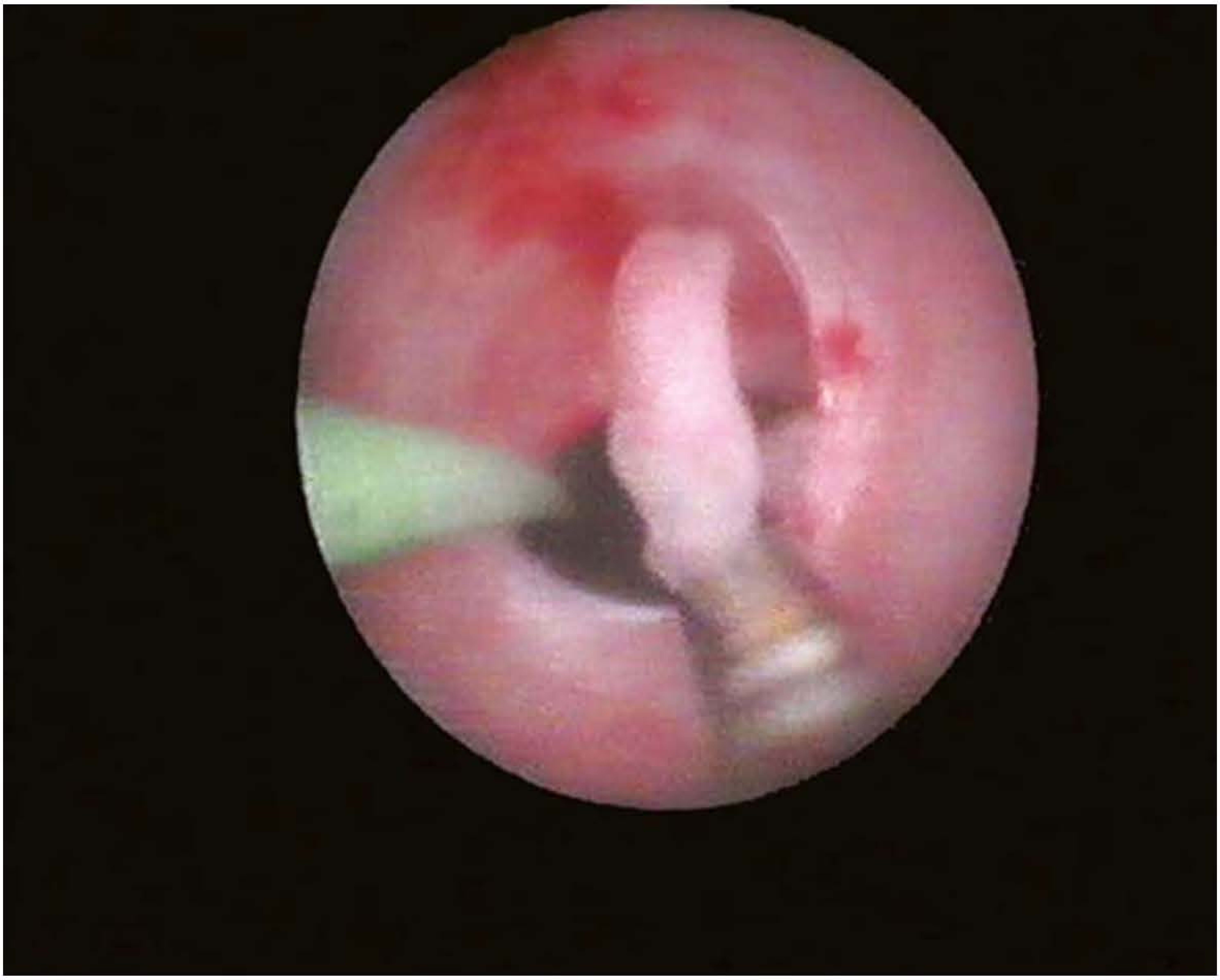

Figure 8.29 **Ureteral tumor removed with a forceps.**

Electroresection of ureteral tumors represented the first option used for the treatment of TCC (Huffman et al., 1985; -Lyon, 2004). Rigid ureteral resectoscopes can be used, similar to an elongated version of pediatric resectoscopes (Fig. 8.30).

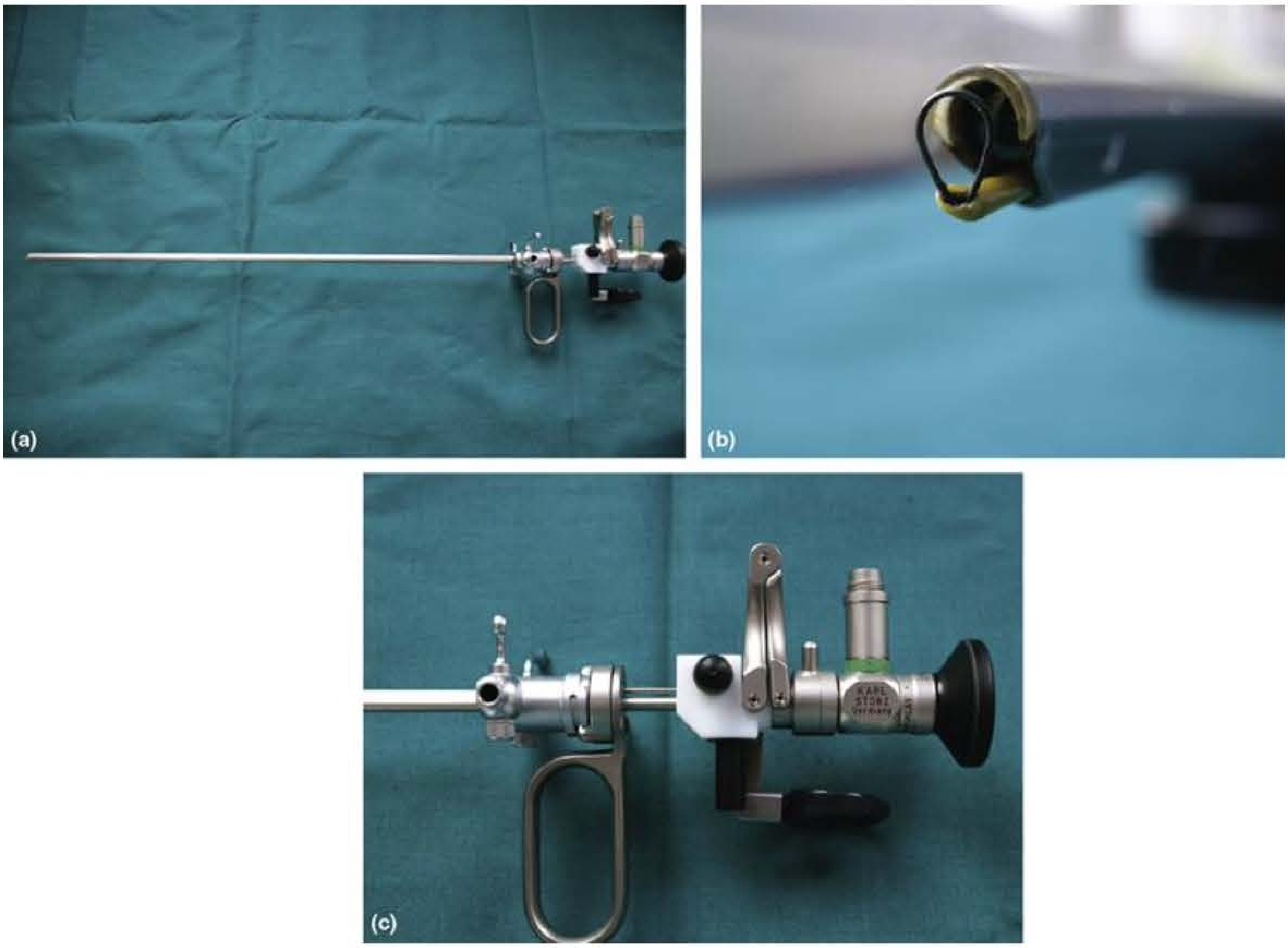

Figure 8.30 **Stortz ureteroresectoscope.**

Large view (a), detail with the mounted loop (b), detail of the working element (c).

However, most have relatively large dimensions, between 12 F and 13 F. The resection loop removes a relatively small fragment of the tumoral tissue, and it may be necessary to clean it before resecting the next piece of tissue (Fig. 8.31).

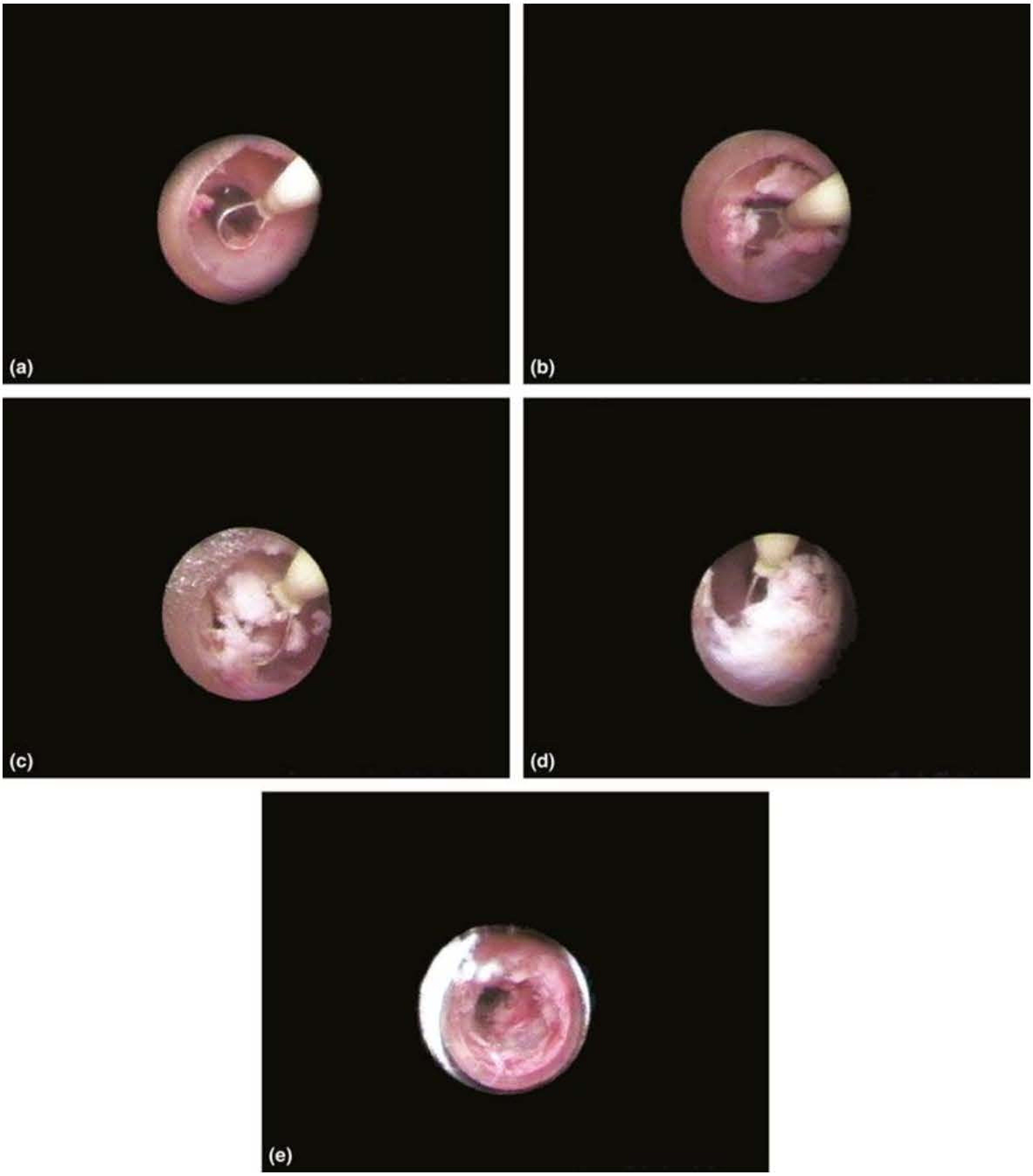

Figure 8.31 **Electroresection for a ureteral tumor (a): progressive resection of the tumor (b–d), final postoperative aspect (e).**

This can prolong the intervention's duration. After resection, the tumor's base can be fulgurated or coagulated with a laser fiber. Resection of the entire thickness of the ureteral or renal pelvis wall, as well as the fulguration of an extended area of the ureter, can determine the consecutive development of iatrogenic strictures (Huffman, 1988).

TCC fulguration can be achieved by using an electrocauterization catheter (Fig. 8.32). This technique is recommended for very small lesions or for a tumor's base consecutive to its resection (Geavlete, 2003a,b). 2–3 F electrocauterization catheters that can be inserted through the working channels of rigid or flexible ureteroscopes are available. As in the case of electroresection, fulguration of extended areas of the ureter should be avoided.

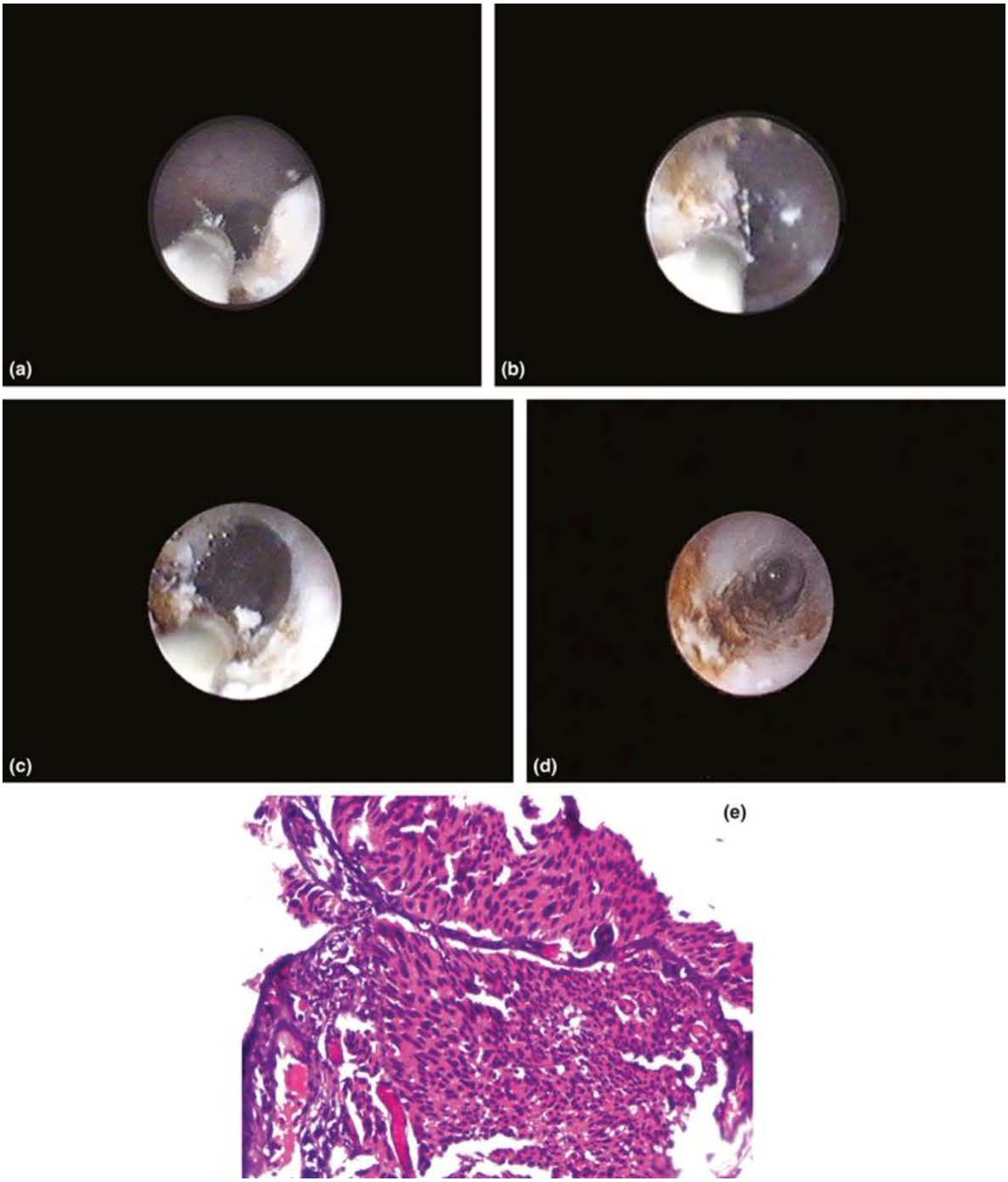

Figure 8.32 **Electric fulguration (a–d) of a pT1G1 ureteral tumor (e).**

Laser techniques are widely applied in the ureteroscopic treatment of upper urinary tract cancers, proving to be more effective than the other alternatives previously described. Small-dimension laser fibers (200–400 μm) can be inserted through the working channel of rigid or flexible ureteroscopes. Three types of lasers can be used: Nd:YAG, Ho:YAG, and Argon.

The Nd:YAG laser was the first laser used both for the treatment of bladder tumors and for TCC vaporization (Malloy, 1985). It was initially used by percutaneous approach, after which it was also used for the ureteroscopic treatment of TCC. In 1989, Schmeller and Hoffstetter demonstrated the success of laser ablation of TCC, with a low rate of postoperative ureteral strictures compared to electrocoagulation.

The penetrability of the Nd:YAG laser is 5–6 mm. This can be controlled by positioning the fiber on the tumor without aiming it directly toward the ureteral wall and by moving it along the tissue's surface in order to avoid prolonged exposure (Bagley, 1998; Geavlete, 2003d) (Fig. 8.33). Secondary damage of the ureteral wall can be limited by orienting the fiber toward the tumor, parallel with the ureter's surface. The Nd:YAG laser can be used safely for tumors located in the renal pelvis, the risk of postoperative stenosis being significantly reduced (Bagley, 1998).

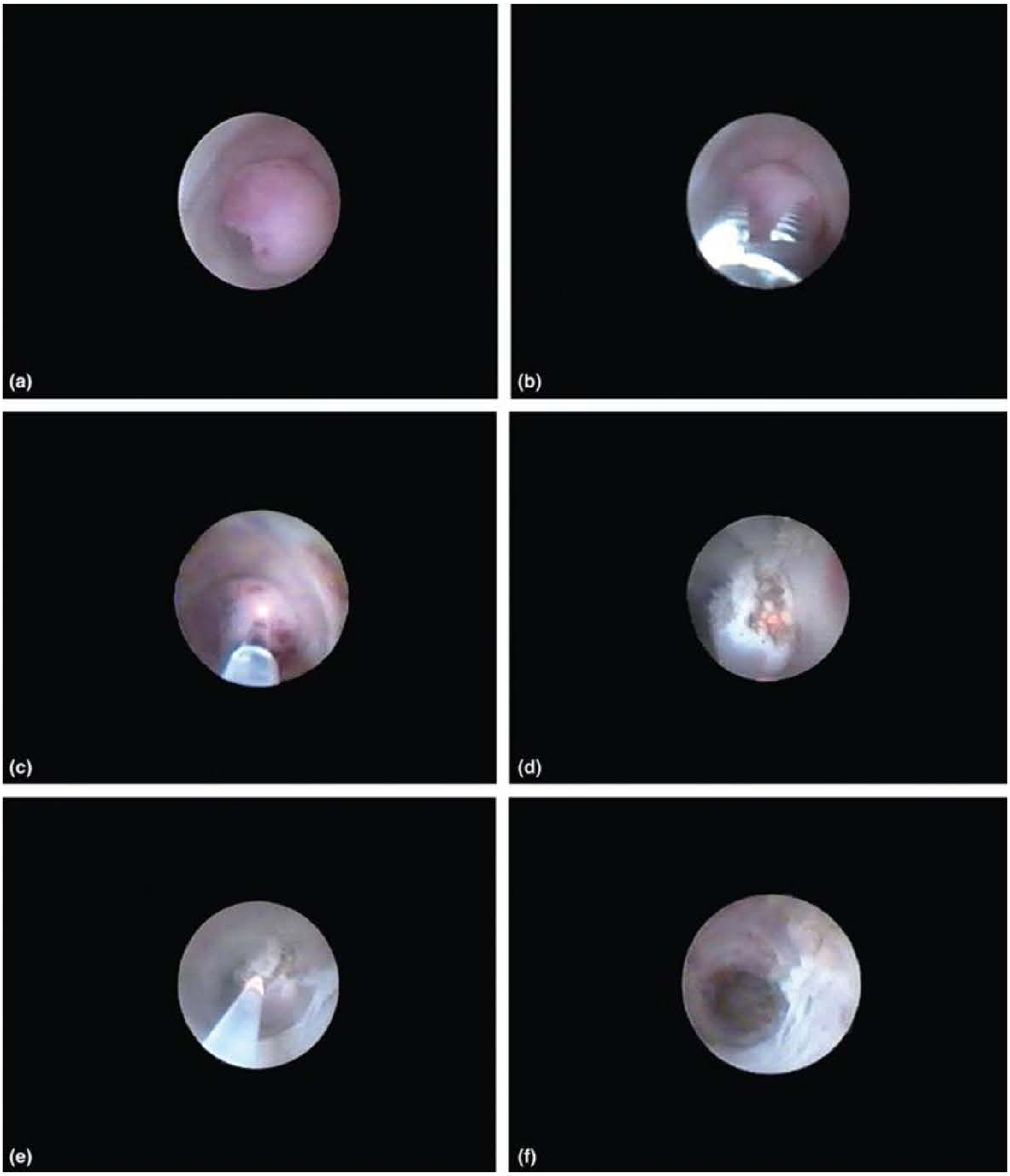

Figure 8.33 **Nd:YAG laser vaporization of a ureteral tumor (a): forceps biopsy (b), noncontact laser coagulation (c–e), final aspect at the end of the intervention (f).**

It is usually recommended to set the laser to a power of 20–30 W, in the continuous mode. Tumoral tissue coagulation is done without touching it (noncontact), by positioning the fiber at a distance of 1–2 mm (Geavlete, 2003d). Tissue decoloration (whitening) indicates an efficient coagulation. For voluminous tumors, removal of the coagulated tissue and subsequently continuing the coagulation of the tumor's base may be necessary.

The Ho:YAG laser is the laser with the largest applicability in urology. It is a pulsed laser that emits light with a wavelength of 2100 nm. Its tissular absorption is reduced, with a penetrability of only 0.5 mm. Therefore, the risk of determining secondary lesions is reduced. The laser fiber must be placed very close or in contact with the tumoral tissue.

Usually, an intensity of 0.5–1 J is used, at a frequency of 6–10 or even 15 Hz (Razvi et al., 1995; Bagley and Erhard, 1995). Maintaining an adequate intraoperative irrigation is important for obtaining a clear visual field. It is often necessary to interrupt the procedure in order to clear the visual field, due to the large amount of cellular debris that is generated. Coagulation is poorer compared to the Nd:YAG laser. Bleeding can be controlled by reducing the energy used or by removing the tissue fiber. The limited penetrability makes it possible to use the Ho:YAG laser without risks even for tumors located at the level of the iliac vessels, renal pelvis, or close to the renal vessels.

The Argon laser theoretically has major advantages for the endoscopic treatment of TCC. Wavelengths between 488 nm and 514 nm are usually used. The penetrability is limited to 1 mm, and the laser wave can be transmitted by a fiber of 300–600 µm. Continuous mode emission is used, the power of the device being set at 5 W.

Many authors recommend the combined use of lasers, the effects of Nd:YAG and Ho:YAG being complementary. Thus, the Nd:YAG laser because of its penetrability can be used to coagulate most of the tumoral volume. The coagulated tissue can be mechanically removed (or even more efficiently with the help of the Ho:YAG laser). The Ho:YAG laser can then be used for the tumor’s base. Thus, the benefits of each type of laser can be used as advantageously as possible.

8.5. Results

The results of ureteroscopic treatment of TCC are encouraging, with a low morbidity and a high efficiency (especially for carefully selected cases) (Table 8.4). Rigid or semirigid ureteroscopic approach has been the most frequently used. The flexible ureteroscope has been preferred for tumors of the proximal ureter or for intrarenal tumors.

Table 8.4

The Results of the Retrograde Treatment of TCC

Author	No.	Technique	Recurrence		NU no.	Follow-up (months)
			Upper urinary tract	Bladder		
Huffman et al. (1985)	8	ER	2	NS	0	18 (2–67)
Schmeller and Hofstetter (1989)	16	Nd:YAG, Nd:YAG + fulg.	3	NS	0	14 (5–49)
Blute et al. (1989)	18	Nd:YAG + fulg.	3	4	0	26 (12–48)
Johnson (1992)	3	Argon laser	1	3	0	11 (5–22)
Grossman et al. (1992)	8	Nd:YAG	5	4	2	20 (12–40)
Tasca et al. (1992)	6	ER	1	NS	1	17 (3–36)
Kaufman and Carson (1993)	9	Nd:YAG	1	NS	0	28 (2–51)
Gaboardi et al. (1994)	18	Nd:YAG	8	NS	1	15 (6–30)
Bales et al. (1995)	3	ER + Nd:YAG	1	NS	0	(24–48)
Engelmyer and Belis (1996)	10	Nd:YAG + fulg.	7	NS	0	(24–66)
Elliot et al. (1996)	37	Nd:YAG + fulg.	17	19	6	60 (3–132)
Martinez-Pineiro et al. (1996)	28	Nd:YAG or ER + fulg.	8	NS	3	31 (2–119)
Keely (1997)	41	Nd:YAG + fulg. and/or Ho:YAG	8	15	8	35 (3–116)
Patel and Fuchs (1998)	13	Ho:YAG and fulg.	3	1	2	16 (6–36)
Grasso et al. (1999)	14	Nd:YAG + Ho, ER	7	4	3	17 (6–31)
Chen and Bagley (2000)	23	Nd:YAG and/or Ho:YAG	15	12	4	35 (8–103)
Elliott et al. (2001)	21	Nd:YAG + fulg.	8	NS	4	73 (12–139)
Iborra et al. (2003)	23	Fulg.	7	NS	2	84.8 (36–210)
Daneshmand et al. (2003)	26	Fulg. or Nd:YAG or Ho:YAG	23	7	3	38 (4–106)
Mugiya et al. (2003)	6	Nd:YAG + Ho:YAG	1	1	1	14
Matsuoka et al. (2003)	27	Nd:YAG + Ho:YAG	10	5	0	35
Yamada et al. (2003)	5	Ho:YAG	0	0	0	10 (4–20)
Suh et al. (2003)	12	Nd:YAG and/or Ho:YAG	9	NS	3	15 (3–48)
Geavlete et al. (2008)	17	ER, Nd:YAG	9	4	4	23.8

NS, nonspecified; ER, electroresection; NU, nephroureterectomy.

The local recurrence rate is approximately 40%, the development of bladder tumors being described in about 35% of cases. The risk of developing a bladder tumor after the ureteroscopic treatment of TCC is significantly higher compared to patients who underwent nephroureterectomy (25–30%). The relatively high rate of bladder tumor occurrence after the ureteroscopic treatment of TCC justifies the periodic cystoscopic follow-up of these patients. Nephroureterectomy was avoided in 88% of cases.

Incomplete tumoral resection, even if the procedure is repeated, represents one of the major problems of the ureteroscopic treatment of TCC, being described in variable percentages of up to 32% (Keely, 1997).

The recurrence rate is directly influenced by tumor grading, being significantly lower for well-differentiated tumors compared to poorly differentiated ones (Keely, 1997). Thus, Martinez-Pineiro, analyzing a group of 28 patients followed for 18 months postoperatively, observed that the recurrence rate after endoscopic treatment recorded variations from 27% for grade 1 tumors to 40% for grade 2 tumors (Martinez-Pineiro et al., 1996). The results were concordant with those obtained by Grasso, who reported a recurrence rate of 45% for well- and moderately differentiated papillary tumors (G1 and G2) treated endoscopically. Keeley and coworkers observed a recurrence rate between 25.7% and 44.4%, depending on tumor grade. Tumors larger than 1.5 cm had a significantly higher rate of local recurrence (50%) compared to small tumors (25%) (Keeley, 1997c).

The careful selection of cases has a direct impact on treatment outcomes, the recurrence rates being significantly lower for cases with elective indication (20% at 33 months) compared to those who had an imperative indication (86%) (Matsuoka et al., 2003).

The existence of multifocal tumors of the upper urinary tract or their association with bladder cancers represented negative prognostic factors, with an increased risk of recurrence.

The initial location of the tumor (ureteral or pyelocaliceal) did not significantly influence the success rate or the recurrence rate. Chen and Bagley reported a higher rate of recurrence, of approximately 65% (15 of 23 patients) due to tumor multiplicity, and they did not observe a significant difference between the recurrence rates of renal pelvis tumors (70%) and ureteral tumors (62%) (Chen and Bagley, 2000).

Most authors conclude that the results of conservative treatment for small tumors (especially those <1.5 cm) are very good. Multifocality and tumor size and grade are important negative prognostic factors that should be taken into consideration when ureteroscopic treatment is chosen (Geavlete et al., 2008). The grade and stage of tumors are usually correlated, which is also reflected in the prognosis of patients. Mufti and coworkers described a survival rate higher than 90% for well-differentiated, superficial TCC, regardless of the therapeutic approach (nephroureterectomy or conservative treatment). Charbit detected tumoral invasion in the superficial muscle layer in 79% of cases of grade 2 or 3 TCC (Charbit et al., 1991).

Theoretically, the greatest risk implied by the biopsy and ureteroscopic treatment of upper urinary tract tumors is represented by the possibility of migration and seeding of malignant cells secondary to increased intrarenal pressure. There are several theories concerning the retrograde migration of malignant cells during ureteroscopy and there are also several reports of tumor seeding secondary to ureteroscopy (Grasso et al., 1992; Lim et al., 1993). On the contrary, there is no evidence of tumor seeding in patients who underwent nephroureterectomy after ureteroscopic biopsy (Hendin et al., 1999).

Recently, Hendin reported that ureteroscopy performed for diagnosis does not have adverse effects on long-term survival in patients with TCC (who subsequently had definitive standard surgical treatment) (Hendin et al., 1999). Bagley (1996) also stated that there is no evidence of diffuse implantation after ureteroscopy and that the recurrence rates, both for upper urinary tract tumors and for bladder tumors, do not differ from those of surgical excision. Although ureteroscopy creates a relatively high pressure, Mugiya et al. (2003) believe that this has no effect on tumor recurrence or on disease-specific survival in patients with TCC.

The use of molecular biology markers as prognostic factors in TCC is controversial and must pass the test of time in order to enter current practice. The most important potential molecular markers are represented by DNA ploidy, blood group, karyotype, p53, cyclin A and E proteins, E-cadherin, oncoproteins, p27, Ki 67, proliferation markers, etc.

8.6. Adjuvant therapy

Due to the high recurrence rate, adjuvant chemotherapy or immunotherapy is an attractive option for the adjuvant treatment of TCC. Although it is not widely used and it has not imposed itself as a standard treatment, the safety and potential benefits of this therapy have been demonstrated in several series of patients.

The first data regarding topical adjuvant therapy in patients with TCC tumors treated endoscopically were published by Streem and Pontes (1986). They used mitomycin C in a patient with a urothelial tumor resected percutaneously. One year later, Smith published the results of a series of nine patients with urothelial tumors resected by percutaneous approach, five of them being treated with adjuvant BCG topical immunotherapy (Smith et al., 1987). Subsequently, several authors reported the use of BCG, mitomycin C, epirubicin, or thiotepa either as primary treatment for CIS or as adjuvant therapy after the endoscopic treatment of TCC. The most frequently used is BCG immunotherapy.

Topical instillation immuno- or chemotherapy can be administered as follows:

- retrogradely through a ureteral catheter
- by vesicoureteral reflux, secondary to the presence of a ureteral stent
- antegradely through the nephrostomy tube

The retrograde technique seems to be more useful for uroteroscopically resected urothelial tumors or when instillation is used as the primary treatment of CIS; the nephrostomy tube is rarely used in these situations. A potential disadvantage of retrograde administration techniques is represented by the fact that the exact amount of therapeutic agent that reaches the previously treated area cannot be assessed. In order to determine the amount of liquid that determines vesico-uretero-renal reflux, some authors recommend performing a cystogram after positioning a JJ catheter. This volume, with values between 80 cc and 250 cc, will be used later during BCG insillations (Irie et al., 2002).

Regarding the antegrade administration through the nephrostomy tube, the main controversy is represented by the possibility of neoplastic dissemination through the nephrostomy tract during the 6 weeks of treatment. However, most authors agree that this risk is reduced. Intrarenal pressure should be closely monitored during antegrade BCG administration, so as not to exceed 25 cm of water. Usually, 1×10^8 colony forming units dissolved in 50 cc of saline are administered in 1 h.

Several studies published in the literature assessed the efficiency of adjuvant immunotherapy (Table 8.5). The recurrence rate varies between 11% and 85%, with an average of 28%. According to tumor grade, the recurrence rate is 25% for G1, 27% for G2, and 35% for G3 tumors, respectively.

Table 8.5

The Results of Adjuvant Immunotherapy for TCC

		Recurrence			
Author	**No. of patients**	**G1 (%)**	**G2 (%)**	**G3 (%)**	**Total (%)**
Schoenberg et al. (1991)	9	1/1	0/6	0/2	1/9 (11)
Martinez-Pineiro et al. (1996)	8	0/1	1/3 (33)	0/2	1/8 (12.5)
Patel and Fuchs (1998)	12	0/6	2/5 (40)	0/0	2/12 (16.7)
Clark et al. (1999)	18	2/6 (33)	2/8 (25)	2/4 (50)	6/18 (33)
Jabbour et al. (2000)	13	–	3/13 (23)	–	3/13 (23)
Thalmann et al. (2002)	14	–	–	–	12/14 (85.7)
Rastinehad et al. (2006)	50	3/10 (30)	6/17 (35)	9/23 (39.1)	18/50 (36)
Total	141	6/24 (25)	14/52 (27)	11/31 (35)	31/110 (28)

Jose et al. (1996) reported that BCG and mitomycin C instillation seem to be effective in preventing recurrences, the rates being reduced to 12.5% and 14.2%, respectively. Patel and Fuchs (1998) treated 12 patients with BCG adjuvant instillations and reported the absence of tumor recurrence in 88% of cases during a mean follow-up period of 14.6 months.

However, in terms of tumor recurrence or progression, some recent studies published by Long Island Jewish Medical Center deny the benefits of topical adjuvant immunotherapy, regardless of the tumor stage or grade (Thalmann et al., 2002). The major complications of BCG instillations in the upper urinary tract are represented by BCG dissemination and by urosepsis with Gram-negative germs, both having a low incidence.

Mitomycin C has also been used as adjuvant therapy for TCC, being well tolerated by patients. Eastham and Huffman reported seven cases with mitomycin C instillations in the pyelocaliceal system through a simple J ureteral catheter or through a percutaneous nephrostomy tube after endoscopic resection. No secondary systemic effects were recorded. Disease progression was observed in only one case (Eastham and Huffman, 1993).

Keeley and coworkers reached a similar conclusion that mitomycin C can be administered without notable side effects, with a reduction of the recurrence rate, especially for high-grade (2–3), multifocal tumors (Keeley and Bagley, 1997). In these cases, the success rate of an adjuvant therapy can be similar to that for small, solitary, low-grade tumors, but without instillation therapy.

8.7. Controversies

8.7.1. Recurrences

Similar to bladder tumors, ureteroscopically treated TCC have relatively high recurrence rates, being impossible to determine whether this fact is due to secondary implantation of cells from the primary tumor or whether there is a connection with the changes of the urothelial field occurring in this condition. Even conservative surgical treatment with open excision of solitary ureteral tumors has relatively high recurrence rates (12–18%), especially in case of proximal localization. Tumors located in the renal pelvis treated conservatively by surgical approach present a higher risk of relapse compared to ureteral localizations (Iborra et al., 2003).

The results of the studies published during the last 5 years indicate an increase of the recurrence rates for ureteral tumors treated ureteroscopically, probably due to a less rigorous selection (the approach of voluminous tumors or of proximal ureteral lesions, etc.). An increase in the number of nephroureterectomies performed in patients initially treated ureteroscopically has also been noted (probably due to the increasing number of cases in which the ureteroscopic approach was preferred as the first alternative).

Most tumoral recurrences are small and can be treated endoscopically (Fig. 8.34) (Geavlete et al., 2003c, 2004). Nephroureterectomy is required when the recurrences are extensive and occur early after the initial treatment (Fig. 8.35). The management of tumoral recurrences will be differentiated according to the particularities of each case and to the type of indication: elective or imperative (Figs 8.36 and 8.37).

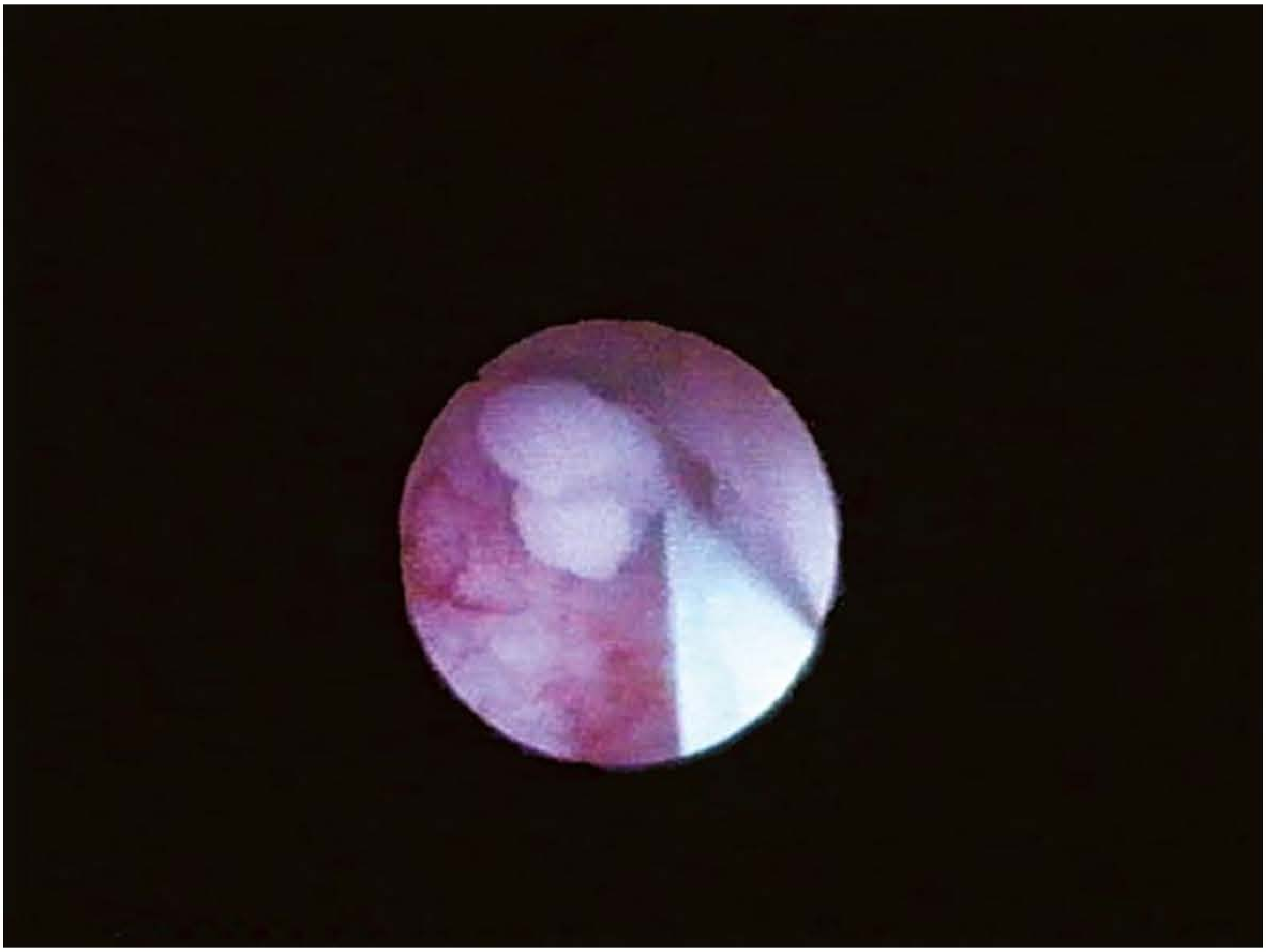

Figure 8.34 **Ureteral tumoral recurrence 12 months after ureteroscopic resection.**

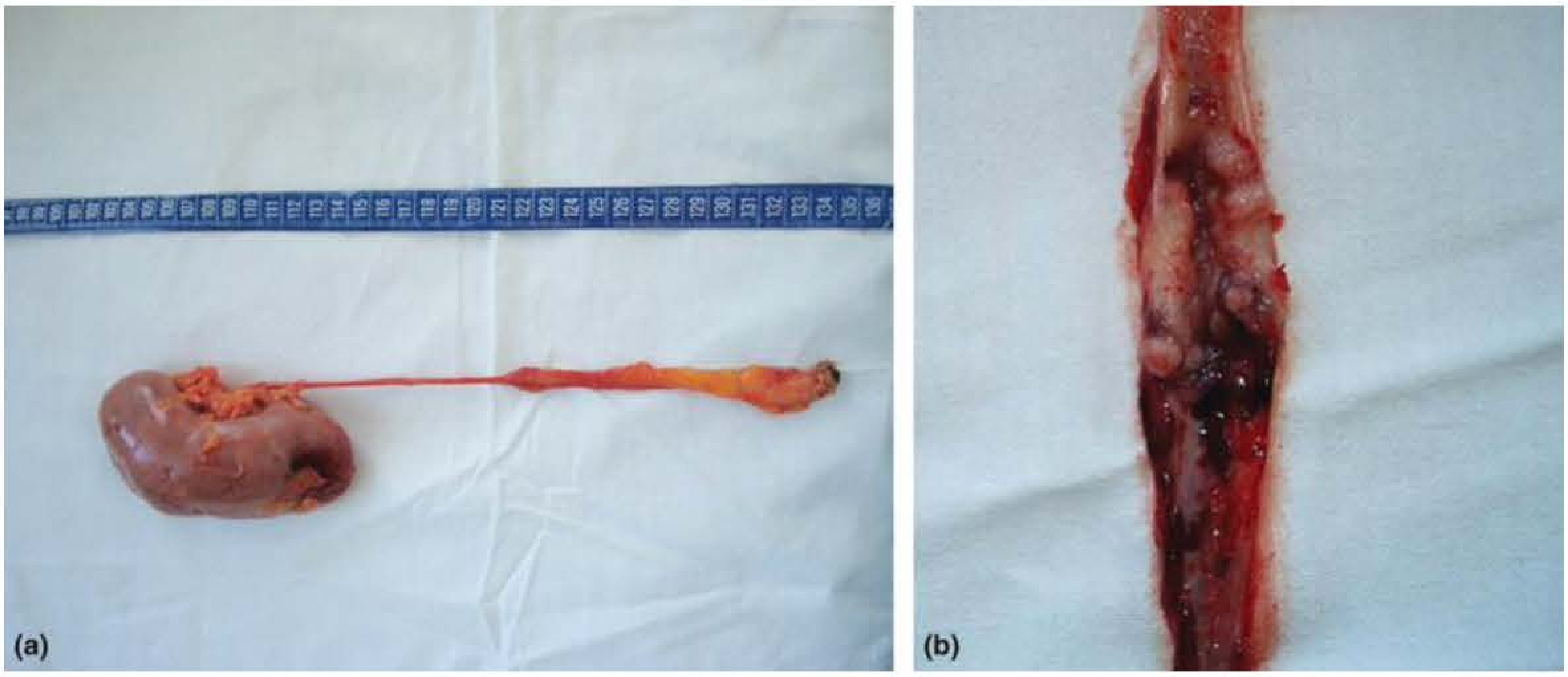

Figure 8.35 Tumor recurrence 3 months after ureteroscopic resection: nephroureterectomy specimen (a) and detail (b).

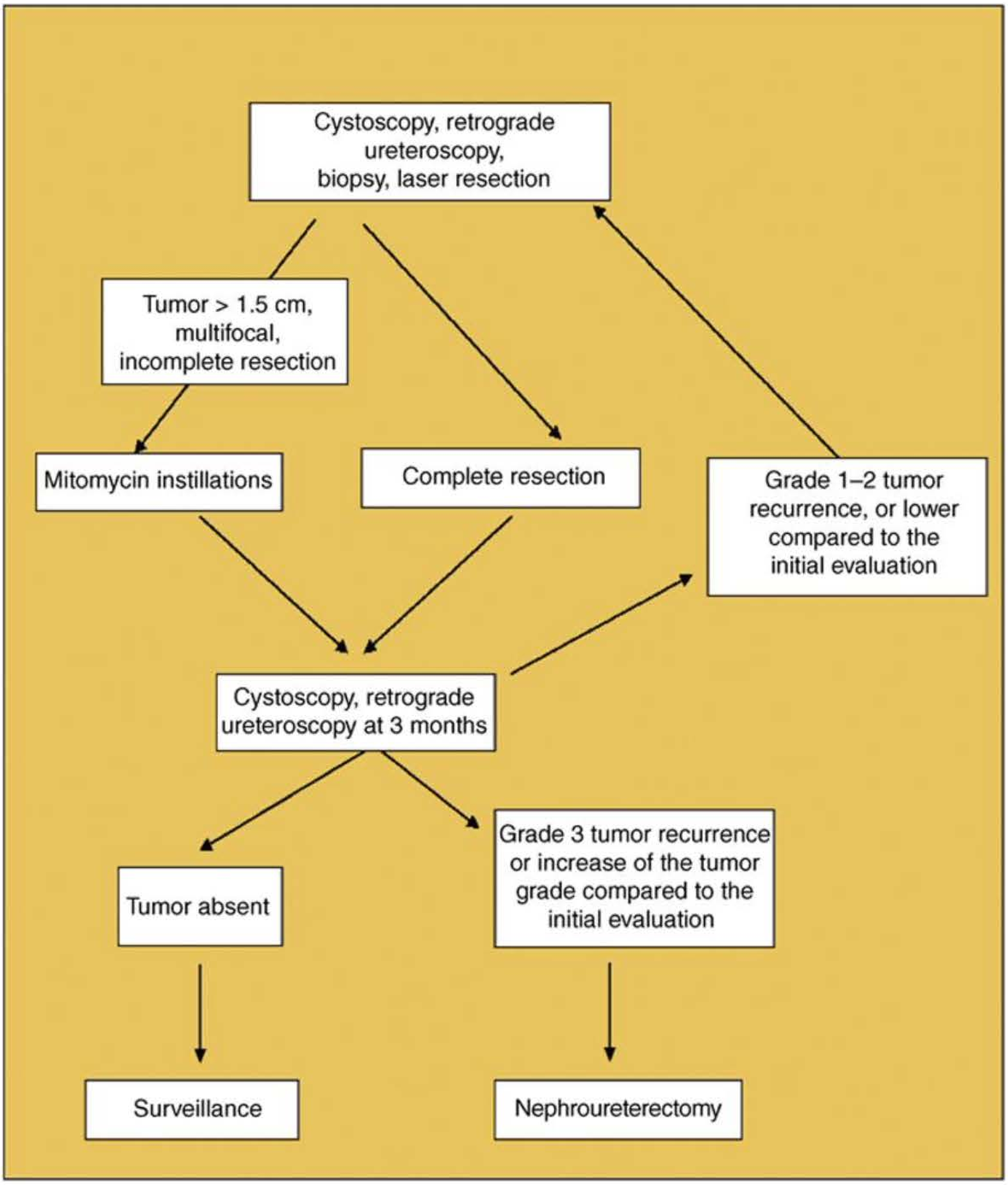
Cystoscopy, retrograde ureteroscopy, biopsy, laser resection
Tumor > 1.5 cm, multifocal, incomplete resection
Mitomycin instillations
Complete resection
Grade 1–2 tumor recurrence, or lower compared to the initial evaluation
Cystoscopy, retrograde ureteroscopy at 3 months
Tumor absent
Grade 3 tumor recurrence or increase of the tumor grade compared to the initial evaluation
Surveillance
Nephroureterectomy

Figure 8.36 **Treatment algorithm for patients with bilateral TCC, single kidney or renal insufficiency.**

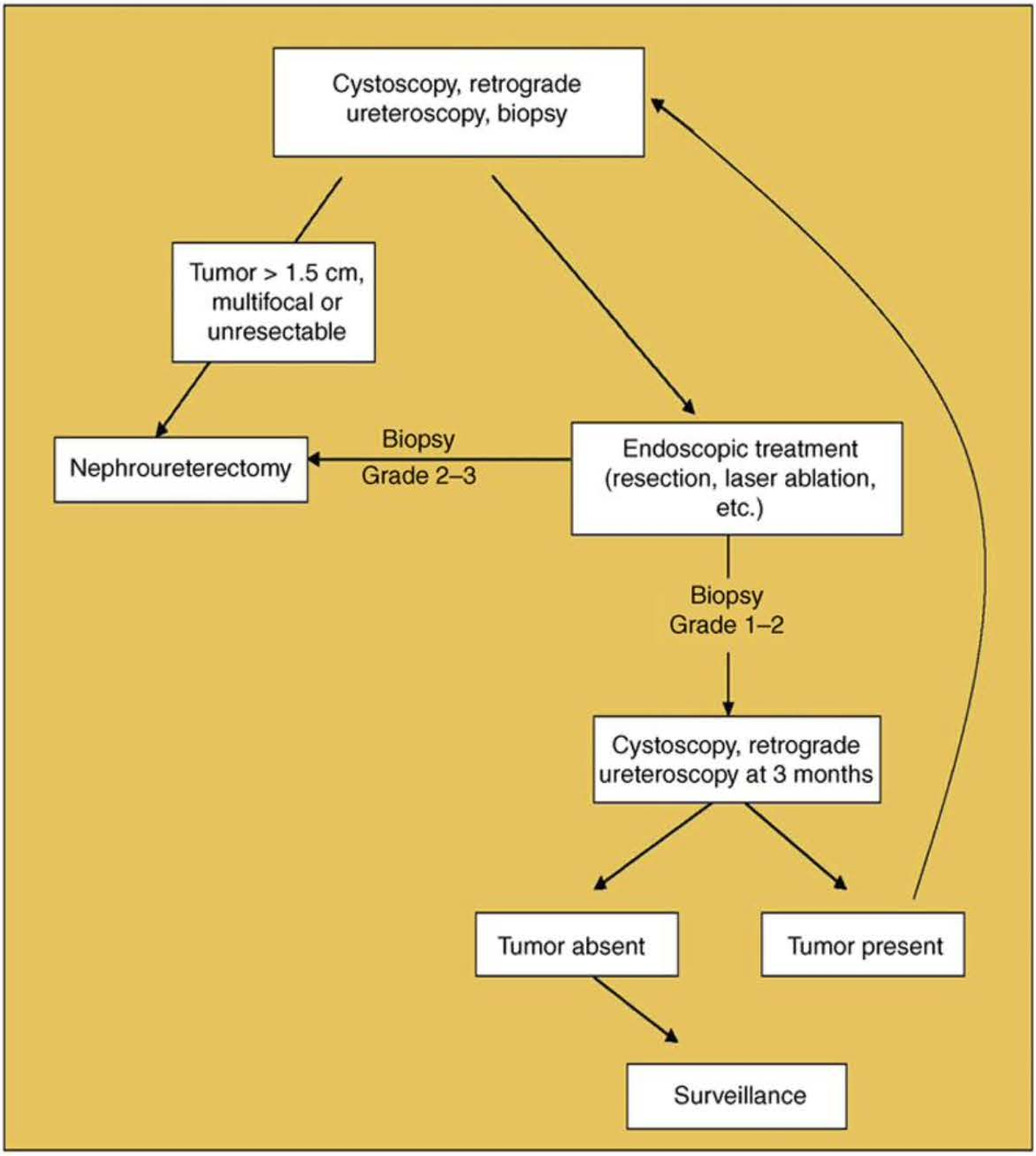
Cystoscopy, retrograde ureteroscopy, biopsy
Tumor > 1.5 cm, multifocal or unresectable
Nephroureterectomy
Biopsy
Grade 2–3
Endoscopic treatment (resection, laser ablation, etc.)
Biopsy
Grade 1–2
Cystoscopy, retrograde ureteroscopy at 3 months
Tumor absent
Tumor present
Surveillance

Figure 8.37 **Treatment algorithm for patients with TCC and normal contralateral kidney.**

Poorly differentiated, multifocal tumors larger than 1.5 cm have a high risk of recurrence, regardless of the type of conservative treatment used (surgical or endoscopic) (Geavlete, 2003a,b). The presence of positive urinary cytology at the moment of diagnosis is also an unfavorable prognostic factor. The location of the primary tumor (pyelocaliceal or ureteral) is an inconstant, controversial prognostic factor.

8.7.2. "*De Novo*" Urothelial Tumors

The risk of developing a bladder tumor (Fig. 8.38) in patients treated for TCC is variable, ranging between 9% and 47%. Some authors claim that there is a direct correlation between this risk and the grading of the primary tumor. Also, tumor multiplicity is a negative prognostic factor regarding the development of bladder tumors (Charbit et al., 1991).

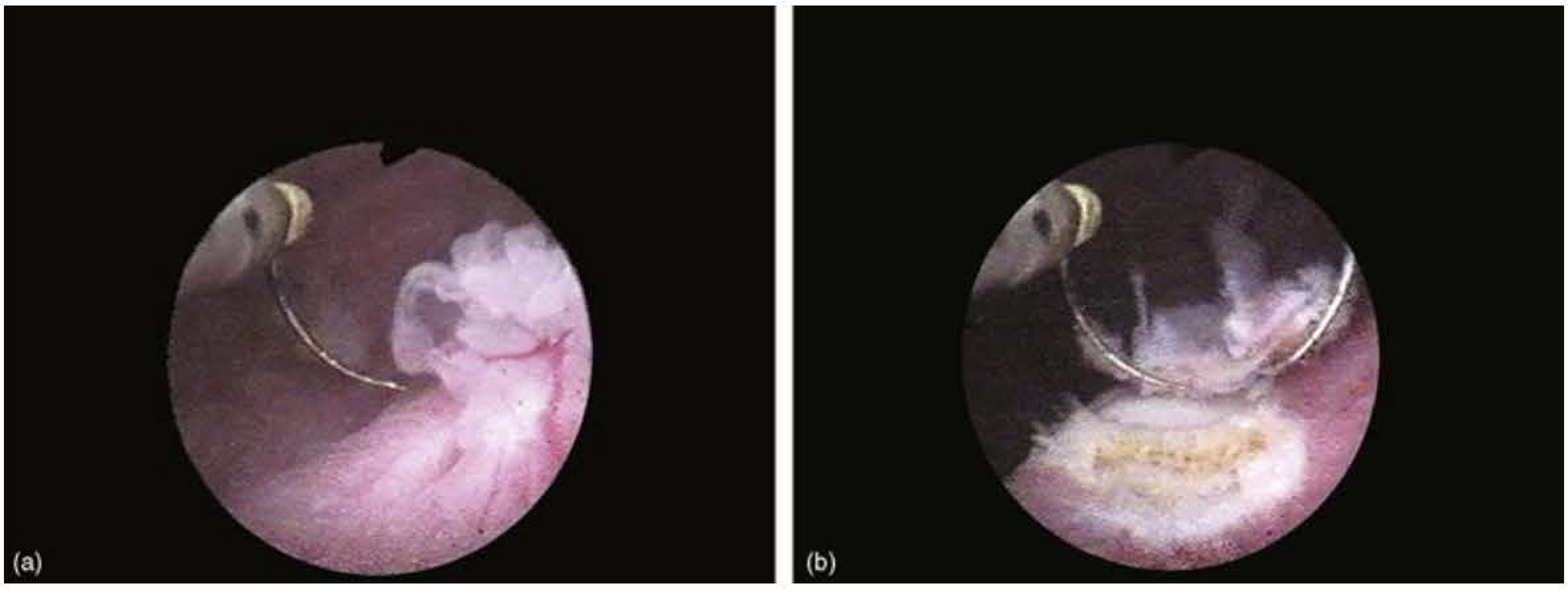

Figure 8.38 Superficial bladder tumor developed 12 months after laser vaporization of a ureteral tumor (a), resected endoscopically (b).

8.7.3. Voluminous Tumors

Some authors recommend ureteroscopic treatment even for voluminous tumors (more than 2 cm) (Fig. 8.39). For these cases, several procedures can be serially applied, repeated at an interval of 8 weeks, period needed for the reduction of the inflammatory lesions secondary to treatment. It is recommended to initially use the Nd:YAG laser (due to its penetrability), followed by Ho:YAG laser vaporization.

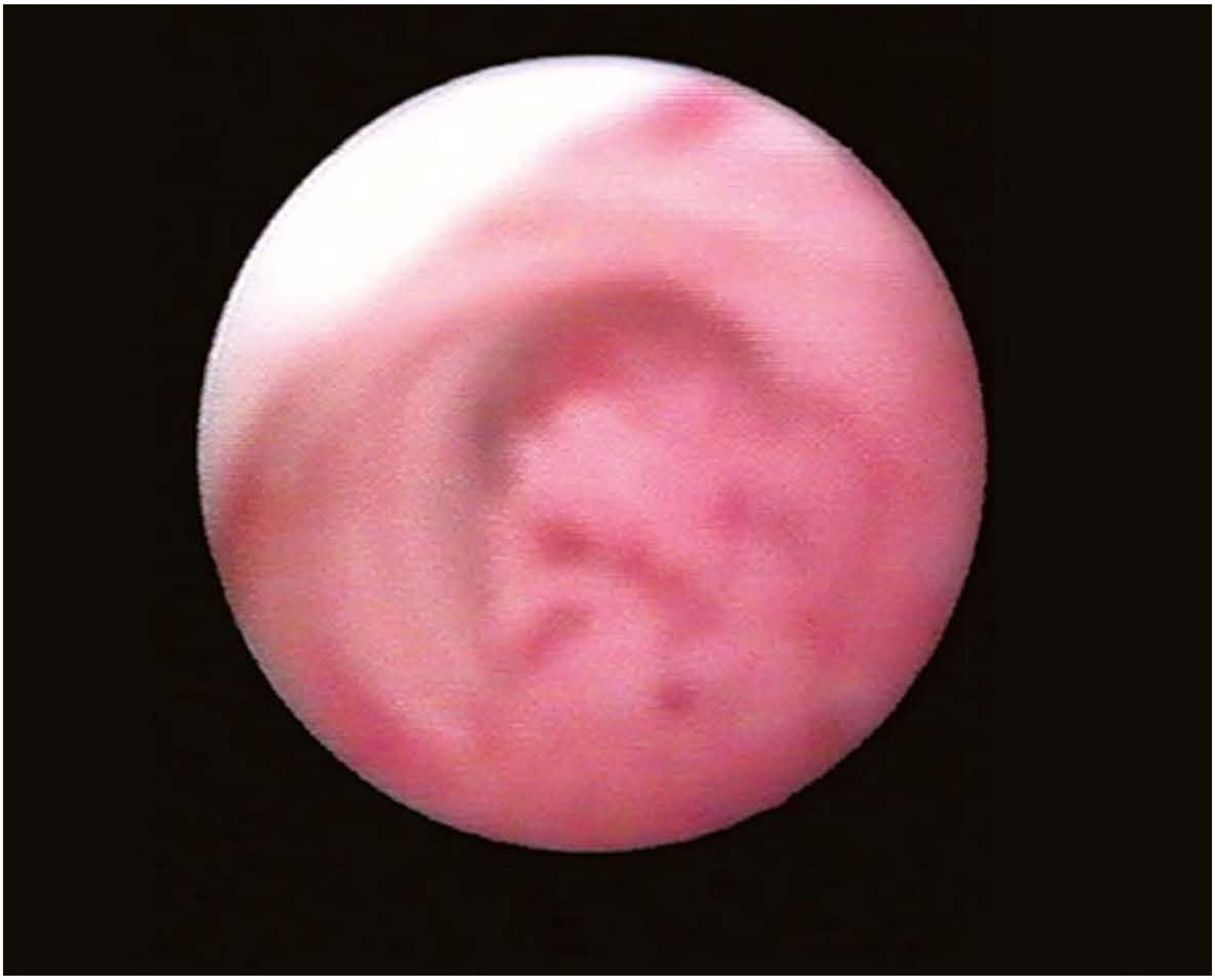

Figure 8.39 Voluminous ureteral tumor.

8.7.4. High-Grade Tumors

Most authors consider that patients with poorly differentiated tumors (Fig. 8.40) are not candidates for ureteroscopic treatment. However, in some circumstances, ureteroscopy can be the only alternative for a patient with TCC, despite the high rate of recurrence (Suh et al., 2003).

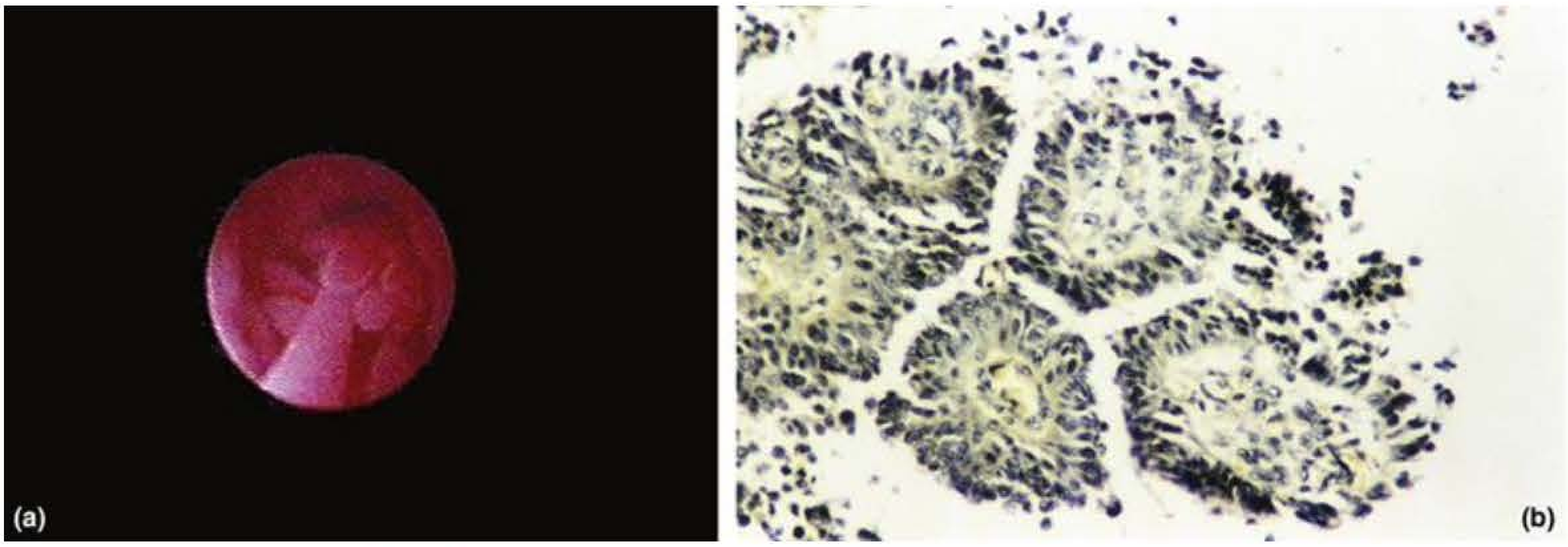

Figure 8.40 **Ureteral tumor (a), poorly differentiated – G3 (b).**

8.7.5. Cases With Normal Contralateral Kidney

Although it does not represent an imperative indication, the ureteroscopic treatment of TCC is increasingly used for patients with normal contralateral kidney (Geavlete et al, 2005a, b). Several series of patients have demonstrated the feasability of this treatment.

Elliot analyzed 21 patients with TCC and normal contralateral kidney (Elliott et al., 2001). Thirty-seven percent of them developed local recurrences after an average period of 7 months after treatment. The recurrence rate was higher for ureteral localizations (46%) compared to pyelocaliceal localizations (12%). Nephroureterectomy was necessary in four cases (19%). Chen and Bagley published a series of 23 patients with TCC and normal contralateral kidney (Chen and Bagley, 2000). Only one case of contralateral tumor recurrence was described, the others being ipsilateral recurrences (recurrence rate – 17%). No case of metastatic disease was described. Nephroureterectomy was necessary in four patients (17%).

In conclusion, the ureteroscopic treatment of TCC can be performed safely and efficiently, preserving the renal units, even in patients with a normal contralateral kidney.

8.8. Complications

The complications described in the literature are general (common for ureteroscopic procedures) and specific. There is a risk of developing retractile scars and stenoses after excessive laser ablation of the tumor and of the adjacent ureter. The risk is probably higher for extensive ureteral tumors. Chen and Bagley reported the occurrence of strictures in 12 of 139 patients (8.6%) (Chen and Bagley, 2000). Elliot, analyzing a group of 54 patients, reported six cases of ureteral strictures, including three patients treated with Nd:YAG laser and three treated with electrocoagulation. Keeley and coworkers reported two patients with ureteral stenoses, one of them being treated with Nd:YAG laser (Keeley, 1997a). However, the same authors did not observe the occurrence of stenoses in another group of 22 patients treated with Ho:YAG laser. An adequate technique must be used in order to avoid the formation of areas of stenosis when using laser therapy – the laser must be activated only when the fascicle is visible and oriented toward the

8.9. Follow-up protocol

Surveillance after the ureteroscopic treatment of TCC is essential due to the high rates of recurrence (Geavlete, 2003a,b). Because of the relatively high risk of developing new tumors in the vesical urothelial field, cystoscopic monitoring of patients after the surgical treatment of TCC is mandatory. There is an opinion that ureteroscopy is the most sensitive procedure and should be routinely used for postoperative follow-up. Bagley included endoscopic surveillance by ureteroscopy at 6-month intervals in the follow-up protocol, and observed that only two of five recurrences from his group were also radiologically detected. Keeley reported a sensitivity of only 25% for retrograde ureteropyelography in detecting recurrent tumors of the upper urinary tract, therefore recommending complete endoscopic follow-up assessment at regular intervals, as in the case of urinary bladder cancers (Table 8.6) (Keeley, 1997a).

Table 8.6

Follow-up Protocol for Ureteroscopically Treated TCC

- 3 months
  - Cystoscopy
  - Cytology
- 6 months
  - Ureteroscopy
- 12 months
  - Intravenous urography or
  - Retrograde pyelography
  - (contralateral kidney assessment)

Chen and Bagley (2000) reported that, compared to ureteroscopy, all the other investigations (urinalysis, retrograde pyelogram, ureteroscopic cytology/biopsy) have a lower accuracy in detecting recurrences of transitional cell carcinoma of the upper urinary tract. This is why they consider that ureteroscopic assessment is essential for surveillance after the endoscopic resection of TCC, and that patients should be followed up by endoscopy in the long term, probably their whole life.

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Chapter

Abstract

The advances achieved in the ureteroscopic techniques, the design of the ureteroscopes, and working instruments have made the endoscopic management of ureteral strictures a reasonable alternative to open surgery. The formation of ureteral strictures is considered to be one of the postoperative complications of lithiasic disease. The development of new endoscopic treatment methods, as well as the improvement of the existing ones, has led to a drop in the occurrence of this complication.

Keywords

balloon dilation
endopyelotomy
ischemic strictures
anastomotic strictures
ureteropyelography
incisional endoscopic treatment
electrocautery
cold knife
metallic stents
uretero-enteral strictures
uretero-vesical reimplantation
JJ

9.1. History

The advances achieved in the ureteroscopic techniques, the design of the ureteroscopes, and working instruments have made the endoscopic management of ureteral strictures a reasonable alternative to open surgery.

The first endoscopic ureteral dilation was described by Pawlick in 1891, who used bougies inserted retrogradely for dilating ureteral strictures in a patient with urinary tuberculosis (Morris, 1901). Nitze (1907) imagined a catheter with a balloon at the proximal end in order to achieve ureteral dilation. Hunner (1924) published the results obtained in a group of 100 patients with ureteral stricures treated by retrograde dilation using a ureteral catheter.

Dourmashkin (1926) published the first results of ureteral balloon dilation as an alternative for the management of ureteral calculi. The author conceived this new device by adapting a rubber balloon at the terminal end of the ureteral catheter. Dilation of the ureteral segment situated distal to the stone was achieved by inflating the balloon, followed by its spontaneous elimination. The development of the balloon dilation technique for the treatment of ureteral strictures was based on this maneuver.

Grüntzig (1978) described a percutaneous transluminal coronary angioplasty by using a 3.0–3.8 mm balloon catheter. Subsequently, these were also used for dilating ureteral strictures, initially by antegrade approach (Pingoud et al., 1980) and then in a retrograde manner (Finnerty et al., 1984). The success rates obtained by the authors in the treatment of these strictures were approximately 83%. Moreover, balloon dilation still continues to represent a widely used therapeutic option.

Davis (1943) described the intubated ureterotomy technique in the treatment of ureteropelvic junction stenoses, as well as in that of strictures located at the level of the proximal ureter. This procedure was first applied in an animal model, later being used successfully in current practice (Davis et al., 1948).

Following the initial studies conducted by Davis, several authors have researched the histological modifications after 4–8 weeks of stenting of an incised ureteral stricture. They confirmed Davis' observation that after ureterotomy, the ureteral musculature regenerates around a catheter (Oppenheimer and Hinman, 1955; McDonald and Calamas, 1960; -Figenshau et al., 1991). The development of modern endourological alternatives was based on this approach in the management of ureteral stenoses.

The contribution of Perez-Castro and Martinez-Pineiro (1980) in improving small-caliber ureteroscopes relaunched the interest for the endourological treatment of ureteral strictures. The appearance of performant optical systems and the miniaturization of instruments have led to the broadening of the diagnostic and therapeutic indications in upper urinary tract conditions. With the introduction of minimally invasive surgical techniques, the treatment of ureteral strictures has registered significant changes. However, with the development of the endoscopic approach of the upper urinary tract, there has been an increase in the incidence of iatrogenic ureteral strictures.

The technique for retrograde endopyelotomy by ureteroscopic approach was described by Clayman and Picus (1988). Karlin et al. (1988a and Motola et al. (1993) published the results of endopyelotomy for the treatment of ureteropelvic junction (UPJ) stenosis obtained in large series of patients with significant follow-up periods. Initially, the technique was indicated only in patients with secondary UPJ stenoses. Due to the similarities between secondary UPJ stenosis and ureteral stenoses, it was considered that the technique could be applied with good results to both conditions, imposing itself as a minimally invasive treatment alternative. Endoureterotomy may presently be performed under direct visual control, minimizing the risk of the formation of strictures due to the trauma induced by the endoscope.

The introduction of flexible instruments for the diagnosis (Marshall, 1964) and subsequently for the treatment (Huffman et al., 1985) of upper urinary tract conditions marked a new step in the management of upper urinary tract stenoses.

The use of the Acucise™ device (Applied Medical Resources, Laguna Hills, CA) was reported by Chandhoke et al. (1993) as a therapeutic alternative for UPJ stenosis, as well as for ureteral strictures. This catheter was imagined with the purpose of simplifying the endopyelotomy technique and of lowering the risk of formation of ureteral strictures secondary to retrograde approach, due to the use of large-diameter rigid ureteroscopes (Meretyk et al., 1992). The Acucise device allows for the treatment of UPJ stenoses and of ureteral strictures by retrograde approach, under fluoroscopic control.

Endoluminal sonography performed intraoperatively (during endoureterotomy) was reported by Goldberg et al. (1991). This procedure contributed to the reduction of the bleeding risk, allowing the surgeon to obtain real-time images of the periureteral vascularization before the

9.2. Generalities

Ureteral strictures can be divided into intrinsic and extrinsic, benign or malignant, and iatrogenic or noniatrogenic. Extrinsic malignant strictures may be secondary to a primary malignant disease (cervix cancer, prostatic adenocarcinoma, bladder tumors, colon cancer) or to a metastatic disease. Extrinsic benign compressions (idiopathic retroperitoneal fibrosis) may determine unilateral or bilateral ureteral obstruction. Intrinsic malignant ureteral obstruction is most frequently secondary to transitional cell carcinoma.

Intrinsic benign strictures of the upper urinary tract may be congenital or secondary. The most frequent localization of congenital ureteral strictures is the ureteropelvic junction. Most ureteral strictures localized at a different level (excepting the UPJ) are secondary, the most frequent being iatrogenic strictures (Wolf et al., 1997) (Fig. 9.1).

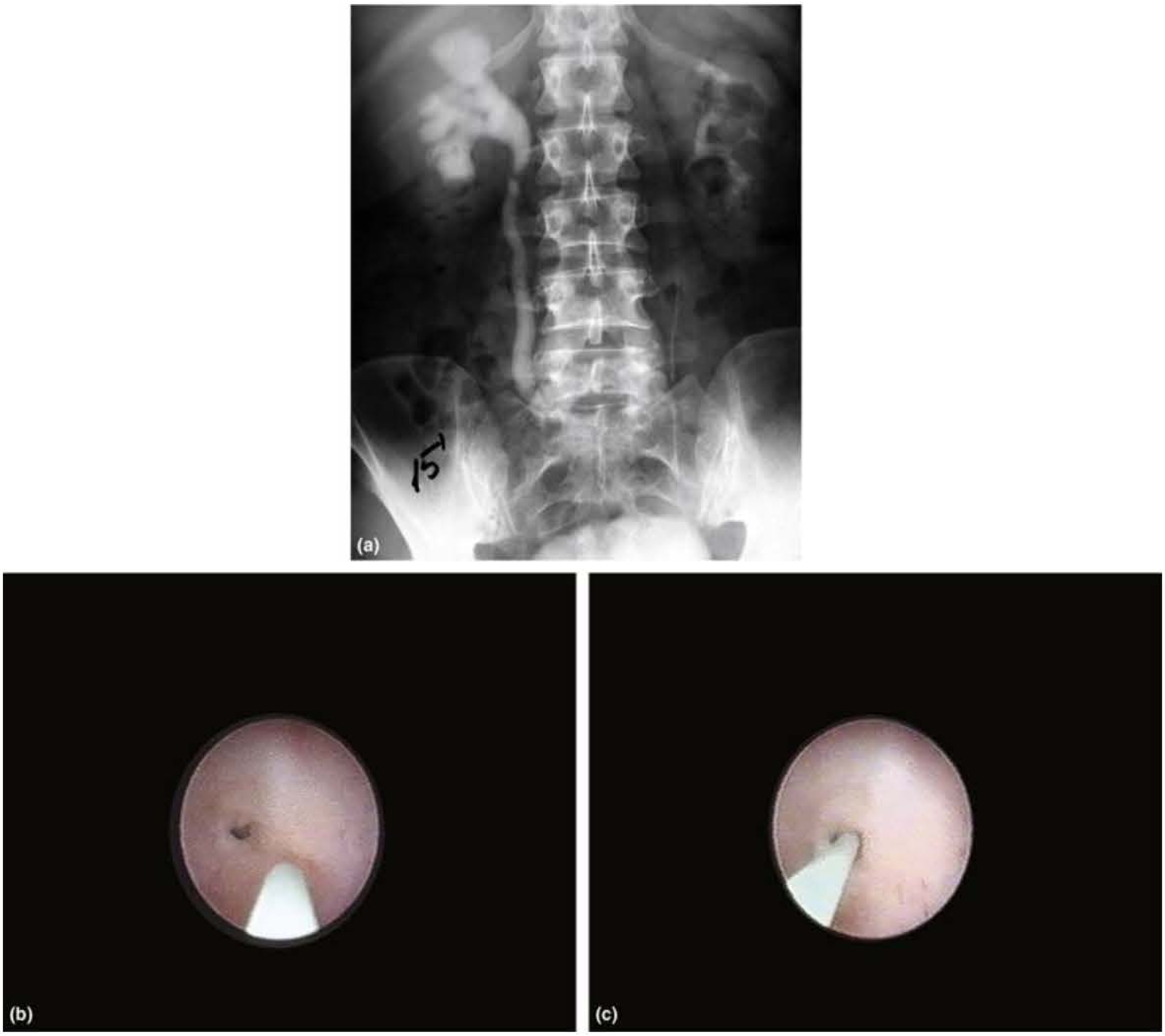

Figure 9.1 **Iatrogenic ureteral stricture at 6 months after ureteroscopy.**
(a) Intravenous urography and (b, c) intraoperative aspect.

The procedures of open, endoscopic, or laparoscopic treatment represent the most frequent causes in the etiology of ureteral strictures. The development of ureteroscopy has led to a 1–11% increase in the incidence of ureteral strictures (Weinberg et al., 1987; Assimos et al., 1994; Selzman and Spirnak, 1996). Gynecological procedures (especially radical hysterectomy), general, or vascular surgery are accompanied by a high risk of developing ureteral strictures (Fig. 9.2).

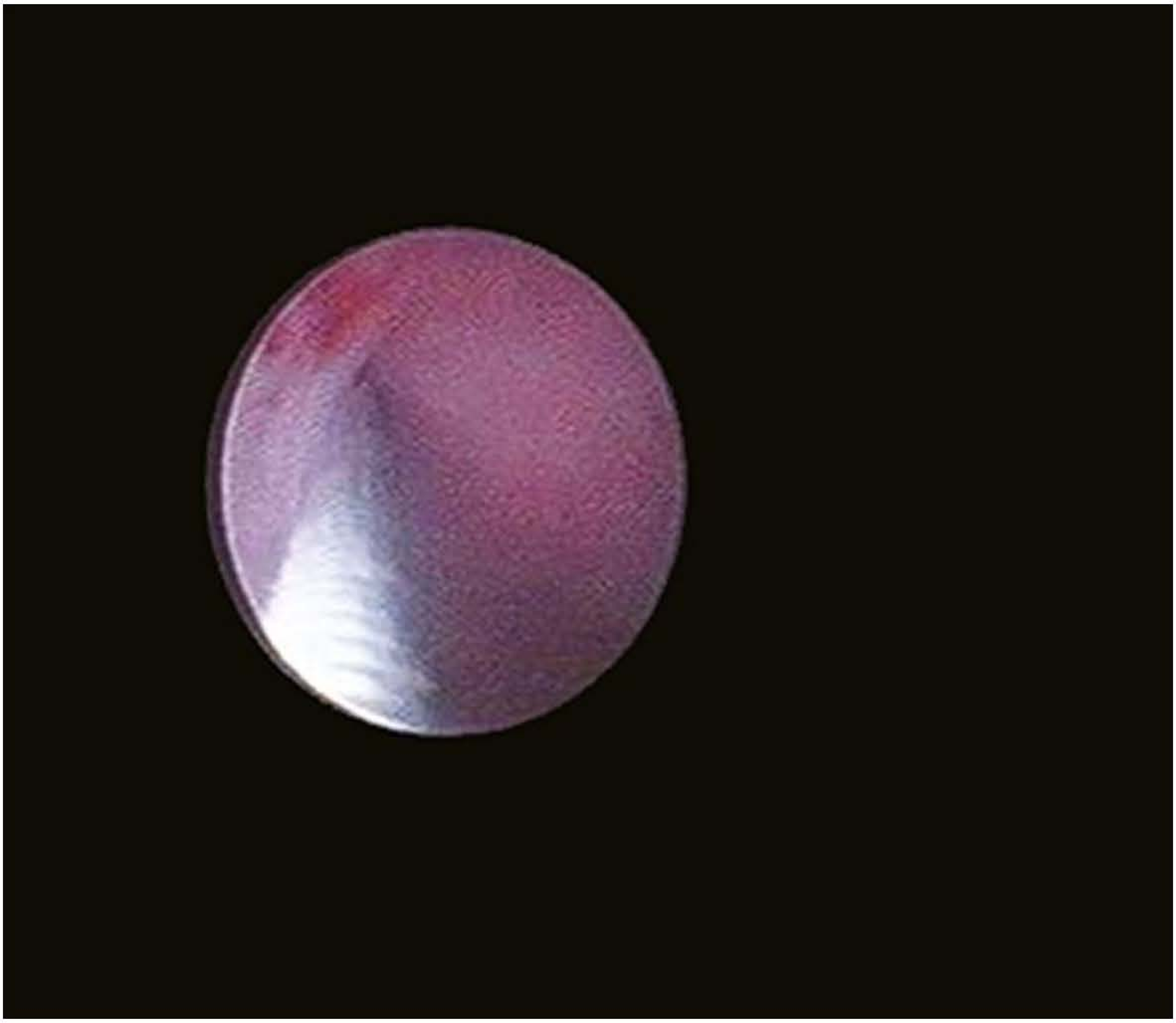

Figure 9.2 **Ureteral stricture after radical hysterectomy.**

Ureteroenteral strictures, after creating urinary reservoirs or after kidney transplantation, represent another pathological entity (Fig. 9.3). Noniatrogenic ureteral strictures include those secondary after the spontaneous elimination of calculi or after chronic inflammatory disease at the ureteral level (such as those that occur in tuberculosis or schistosomiasis) (Sabha et al., 1988; Ramanathan et al., 1998).

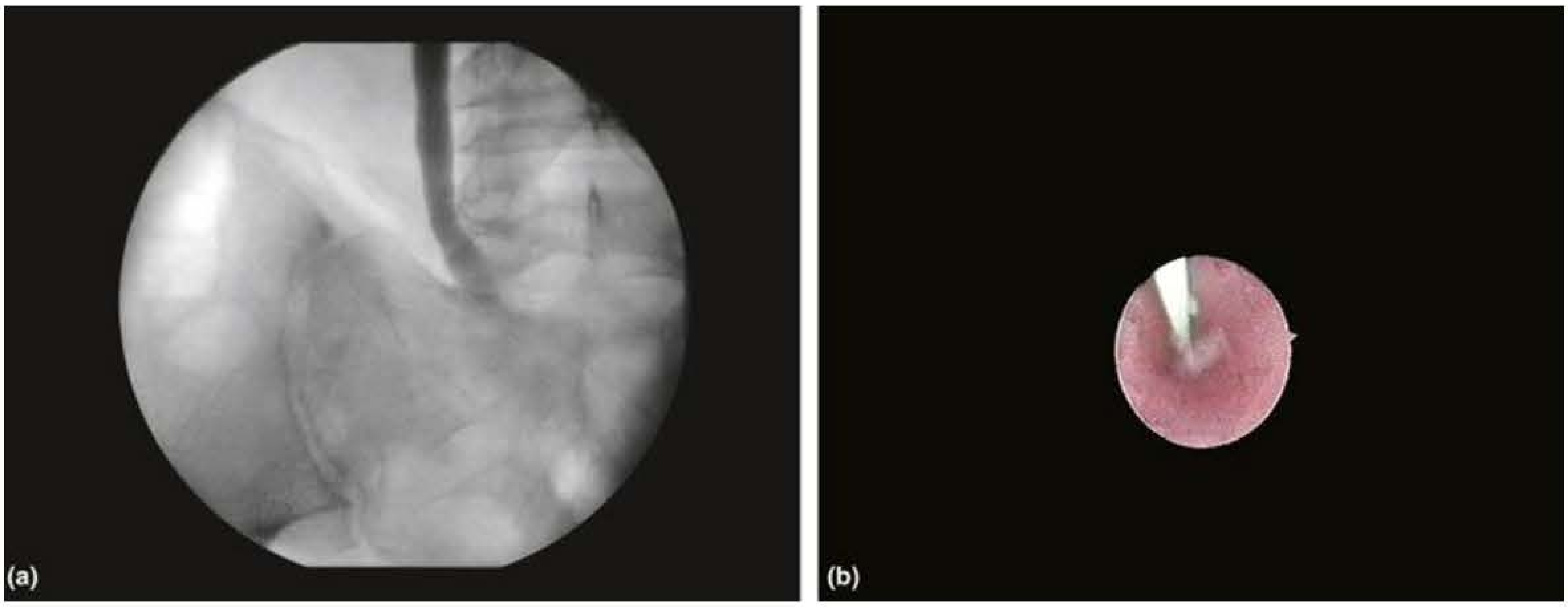

Figure 9.3 **Ureteral stricture after ureterosigmoidostomy.**

(a) Intraoperative fluoroscopic and (b) endoscopic aspect.

From the point of view of the etiopathogenic mechanism, benign ureteral strictures can be classified into ischemic or nonischemic (Wolf et al., 1997). Thus, ischemic strictures can be consecutive to open surgical procedures or to radiotherapy, while the nonischemic ones are congenital or secondary to the spontaneous elimination of calculi.

The formation of ureteral strictures is considered to be one of the postoperative complications of lithiasic disease, with an incidence of up to 5% (Fig. 9.4). The development of the new endoscopic treatment methods, as well as the improvement of the existing ones, have led to the decrease in the incidence of this complication. Thus, a reduction in the incidence of ureteral strictures after ureteroscopy from 1.4% in 1982 to 0.5% in 1992 was observed. The treatment of impacted ureteral calculi can be difficult in the incidence of local modifications such as edema and epithelial hypertrophy. These modifications can be responsible for the formation of strictures and can increase the risk of ureteral lesions during endoscopic maneuvers (Herman, 1992).

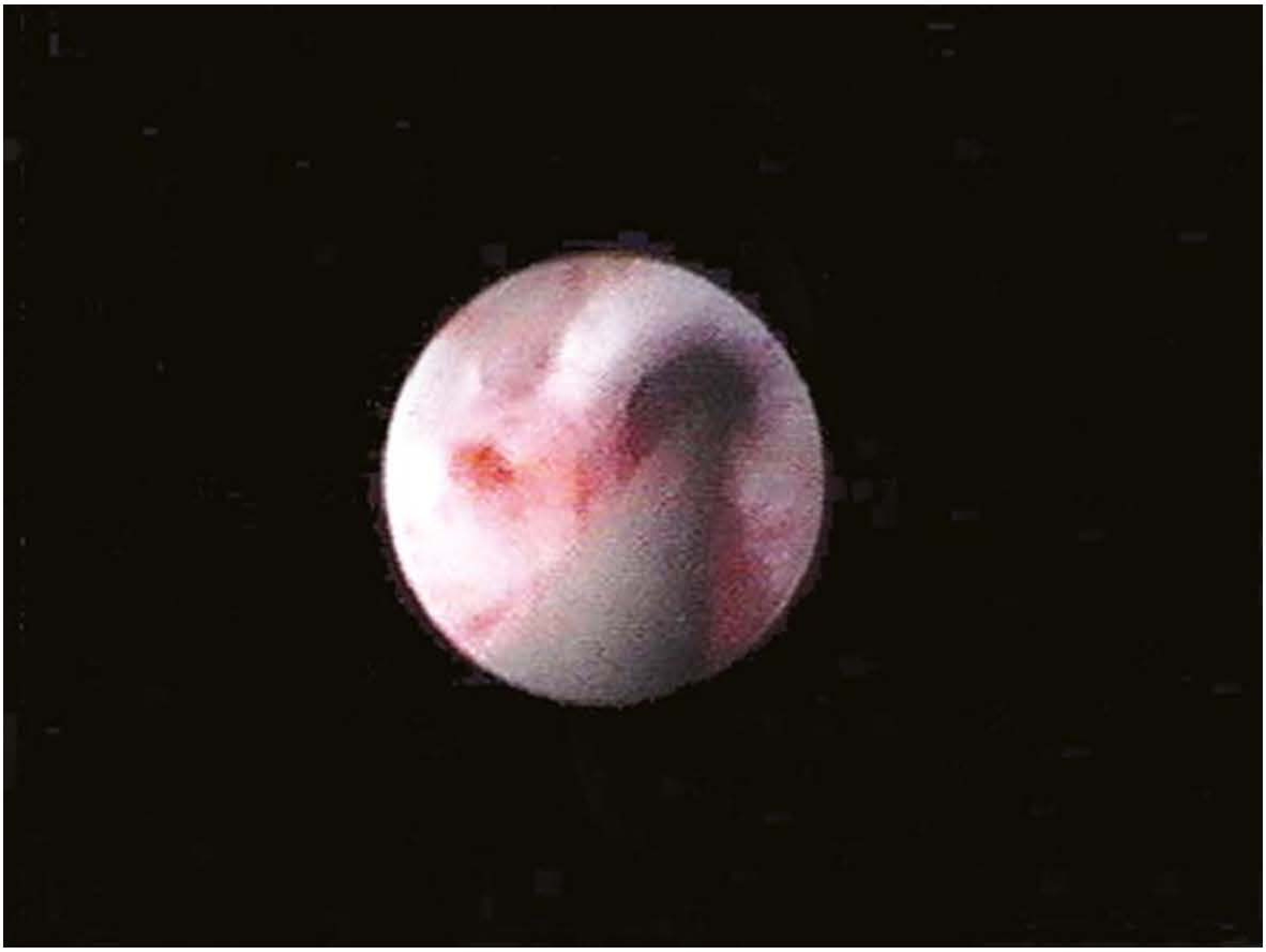

Figure 9.4 **Ureteral stricture secondary to an impacted ureteral stone.**

The intimate mechanism of the formation of ureteral strictures has not been completely elucidated, but it is considered to be multifactorial. Thus, mechanical-type lesions (perforations, avulsions), relative ischemia occurring due to the use of large-caliber instruments, or thermal lesions are considered to be the main factors involved in the appearance of ureteral strictures. It has been demonstrated that strictures are the consequence of an inflammatory process secondary to the intraoperative injury of the urothelium. The ureteral mucosal lesions are followed by the appearance of a fibrinous exudate that precipitates in the traumatized areas, adheres to them, and in the end, favors the appearance of the stricture. Periureteral fibrosis is the consequence of urinary leakage, especially when a superimposed infection exists.

The improvement of instruments and of endoscopic surgical techniques has allowed for a reduction in the incidence of ureteral mucosal lesions and, implicitly, in the risk of triggering the physiopathological mechanisms involved in the development of iatrogenic stenoses (Harmon et al., 1997).

The data regarding the etiopathogenic mechanisms of strictures do not distinguish between those due to calculi impacted for a long period of time and those secondary to acute obstruction. Some authors have defined an impacted stone as being the stone that does not allow ureteral catheterization with the help of a metallic guidewire. This definition is incomplete and imprecise because it refers to a transient situation (position) of the stone. In the opinion of many authors, impaction requires maintaining the stone in the same position for a period of over 2 months. Impacted ureteral calculi determine distinct histological modifications at the level of the ureteral wall (Fig. 9.5). Histological studies have shown the presence of chronic inflammation, interstitial fibrosis, and mucosal hypertrophy at the level of impaction. Ureteral edema and fibrosis may appear through ischemia secondary to chronic hyperpressure or to an immunological reaction triggered by the stone. These modifications result in the adherence of the stone to the urothelium and increase the risk of ureteral lesions during the endoscopic maneuvers. The incidence of ureteral strictures after the ureteroscopic treatment of such calculi may reach 24% (Roberts et al., 1998).

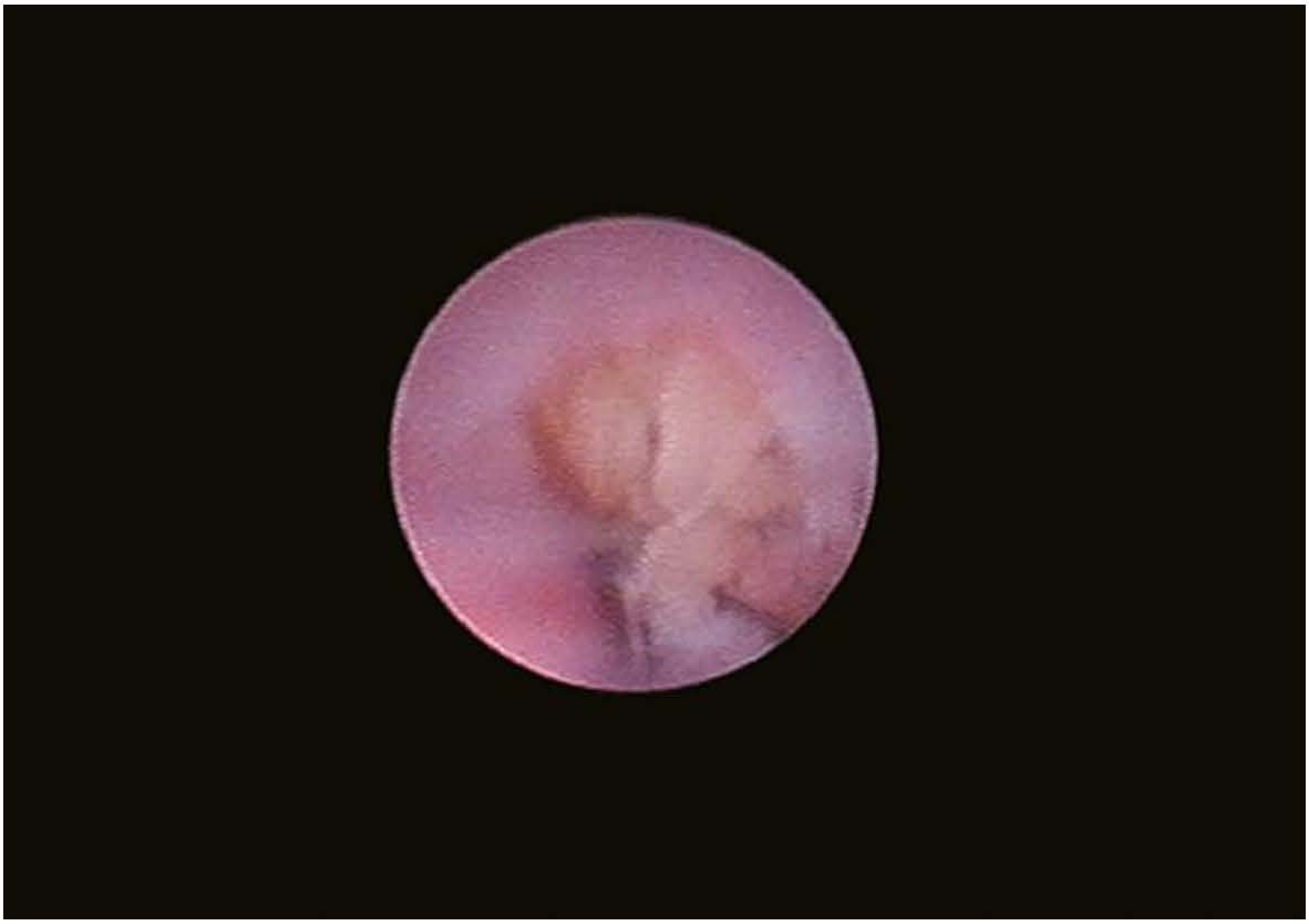

Figure 9.5 **Impacted ureteral stone.**

In the case of ischemic strictures, frequently associated with fibrosis and vicious scars, the success rate of endoureterotomy is relatively low (Thomas, 1993). Strictures that occur consecutive to cystectomy and urinary derivations represent a special subgroup within ischemic strictures (the subgroup that is most difficult to treat). The fact that most strictures occur on the left side has led to the hypothesis that excessive ureteral mobilization, adventitial stripping, and a rectilinear trajectory (with a narrow tunnel beneath the mesosigmoid), constitute the main favoring factors (Sullivan et al., 1980). The global incidence of anastomotic strictures after urinary derivations ranges from 3% to 9% (Weijerman et al., 1998; Novotny et al., 2004). Many authors consider that the type of anastomosis represents a significant risk factor, the antireflux anastomoses presenting a doubled risk compared to large ones, with reflux (7–14% vs. 3–7%) (McDougal, 2002).

The strictures of the uretero-vesical junction (Fig. 9.6) most frequently occur after kidney transplantation, especially when the cases are complicated with ischemia of the ureter's distal segment, as well as with the possible rejection of the allograft (Streem et al., 1988; Bhayani et al., 2003). This problem can also occur after transurethral biopsy that involved the ureteral orifice.

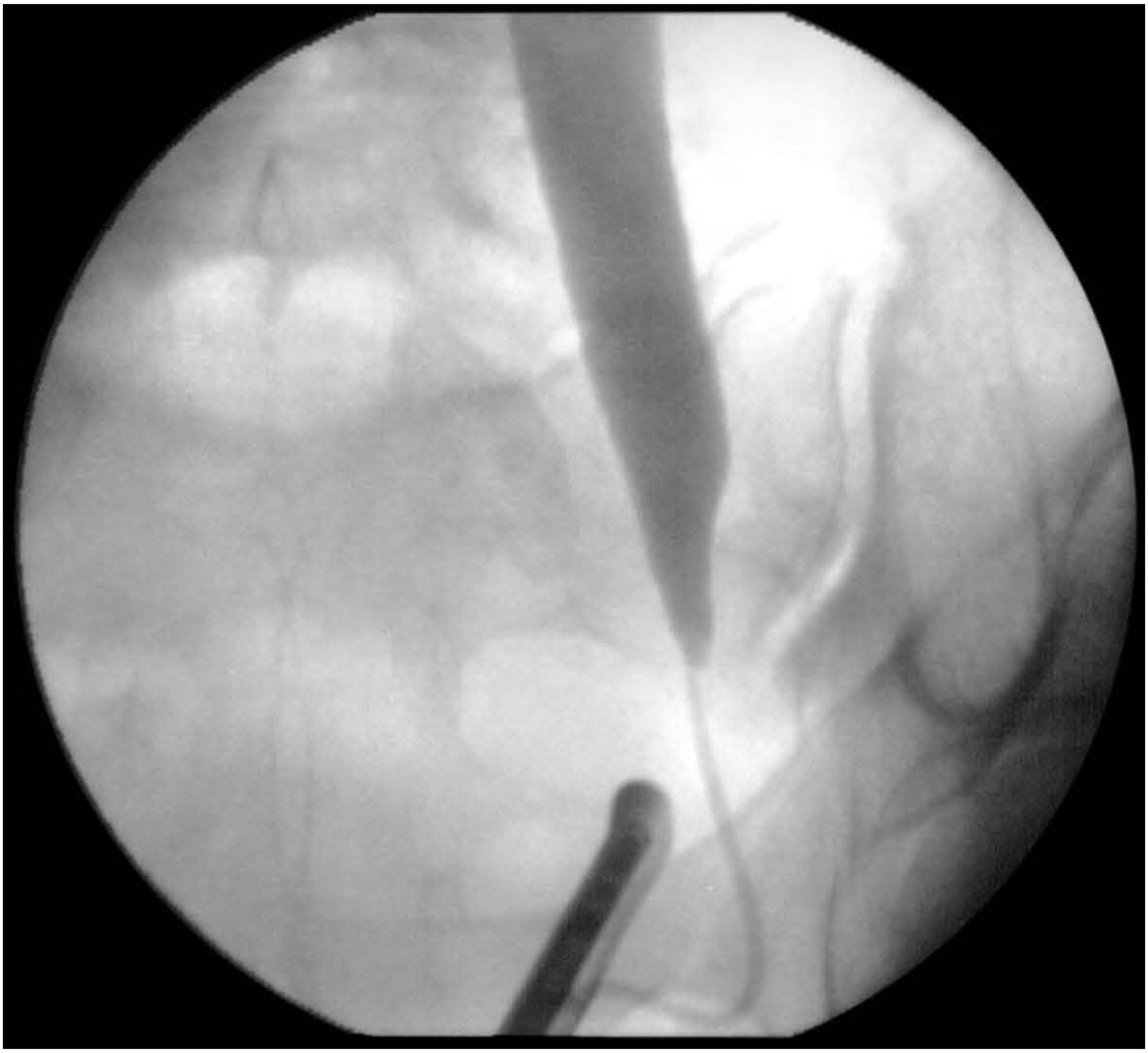

Figure 9.6 **Ureteral stricture after Casati Boari uretero-vesical reimplantation.**

Ureteral lesions secondary to pelvic or retroperitoneal interventions may represent etiological factors for the development of iatrogenic stenoses. The most frequently incriminated are interventions in the genital region, the iatrogenic ureteral lesions in such cases being described with an incidence ranging from 0.02% to 2.5% (Vakili et al., 2005). The risk factors are represented by malignant lesions, pelvic irradiation, endometriosis, surgical interventions for prolapse, etc.

9.2.1. Preoperative Assessment and Preparation

The clinical picture of patients with ureteral strictures may vary: some present flank pain; others may present hematuria, urinary tract infections, or a combination of these symptoms. Up to 25% of patients are asymptomatic, despite significant obstruction (Eshghi and Lifson, 1995). Many of these cases are discovered in patients followed postoperatively after ureteroscopy or urinary derivations. However, most patients with iatrogenic ureteral strictures after ureteroscopy are symptomatic (Karod et al., 1999). Patients with a single kidney or with bilateral affection may present decompensated kidney insufficiency.

The first-line imagistic exploration is represented by abdominal ultrasonography. Although this can detect hydronephrosis, intravenous urography (Fig. 9.7) or retrograde utereropyelography (Fig. 9.8) is absolutely necessary for assessing the level and degree of obstruction.

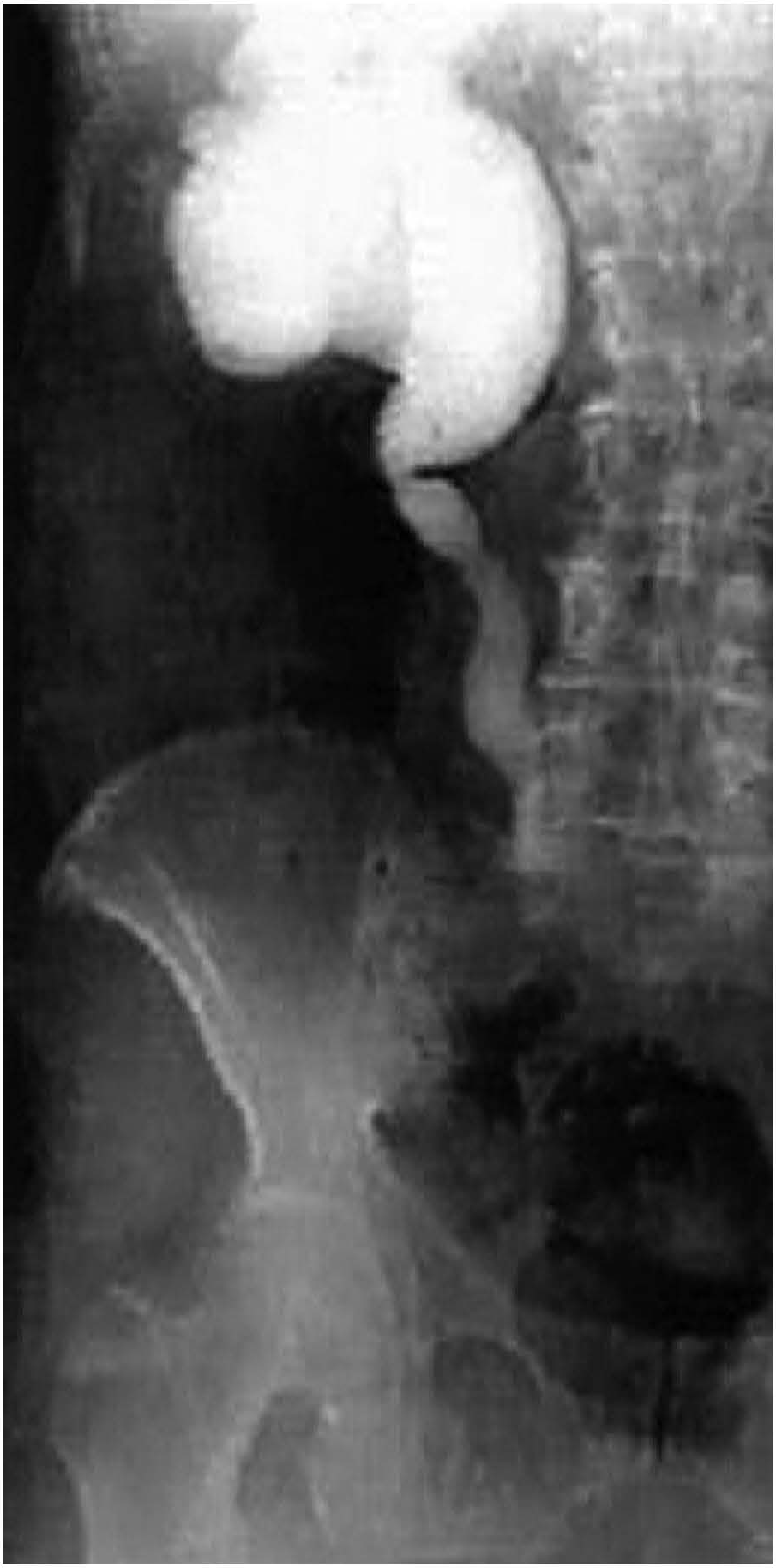

Figure 9.7 **Intravenous urography in a patient with right pelvic ureteral stricture.**

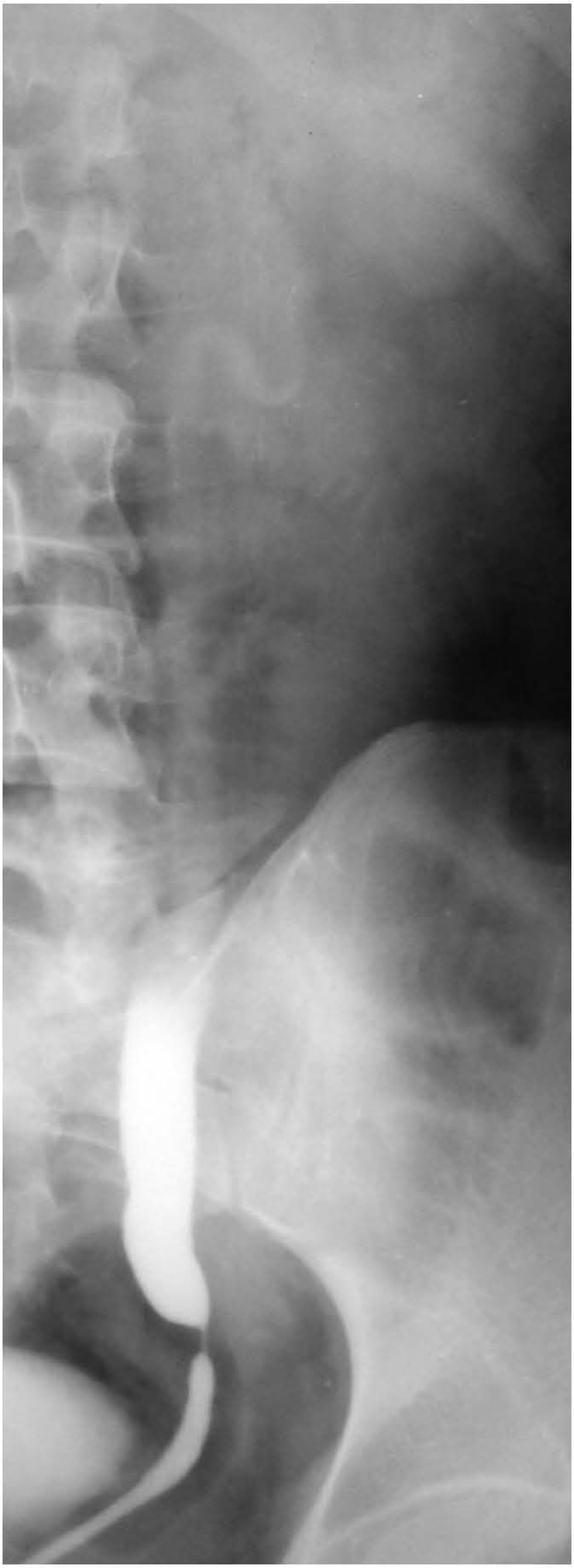

Figure 9.8 **Retrograde ureteropyelography in a patient with juxtavesical ureteral stenosis.**

Helical (spiral) computed tomography occupies an increasingly important place in the assessment of ureteral strictures, due to the fact that it provides additional anatomic details with regard to the neighboring vascularization compared to standard ureteropyelography (Caoili et al., 2002).

If the presence of an obstruction is equivocal, renal scintigraphy with diuretic nephrogram usually represents the elective diagnostic modality (Krueger et al., 1980). Difficult cases may require a pressure-flow study in order to establish the definitive diagnosis (Whitaker test).

Endoluminal ultrasonography (Fig. 9.9), with or without tridimensional reconstruction, may be recommended for the preoperative assessment of ureteral strictures. Its advantages are represented by the possibility of detecting submucous or periureteral lesions (aberrant vascular structures, fibrosis, etc.) (Benjamin and Christopher, 2006). However, the method is invasive and cannot be used in complete ureteral stenoses.

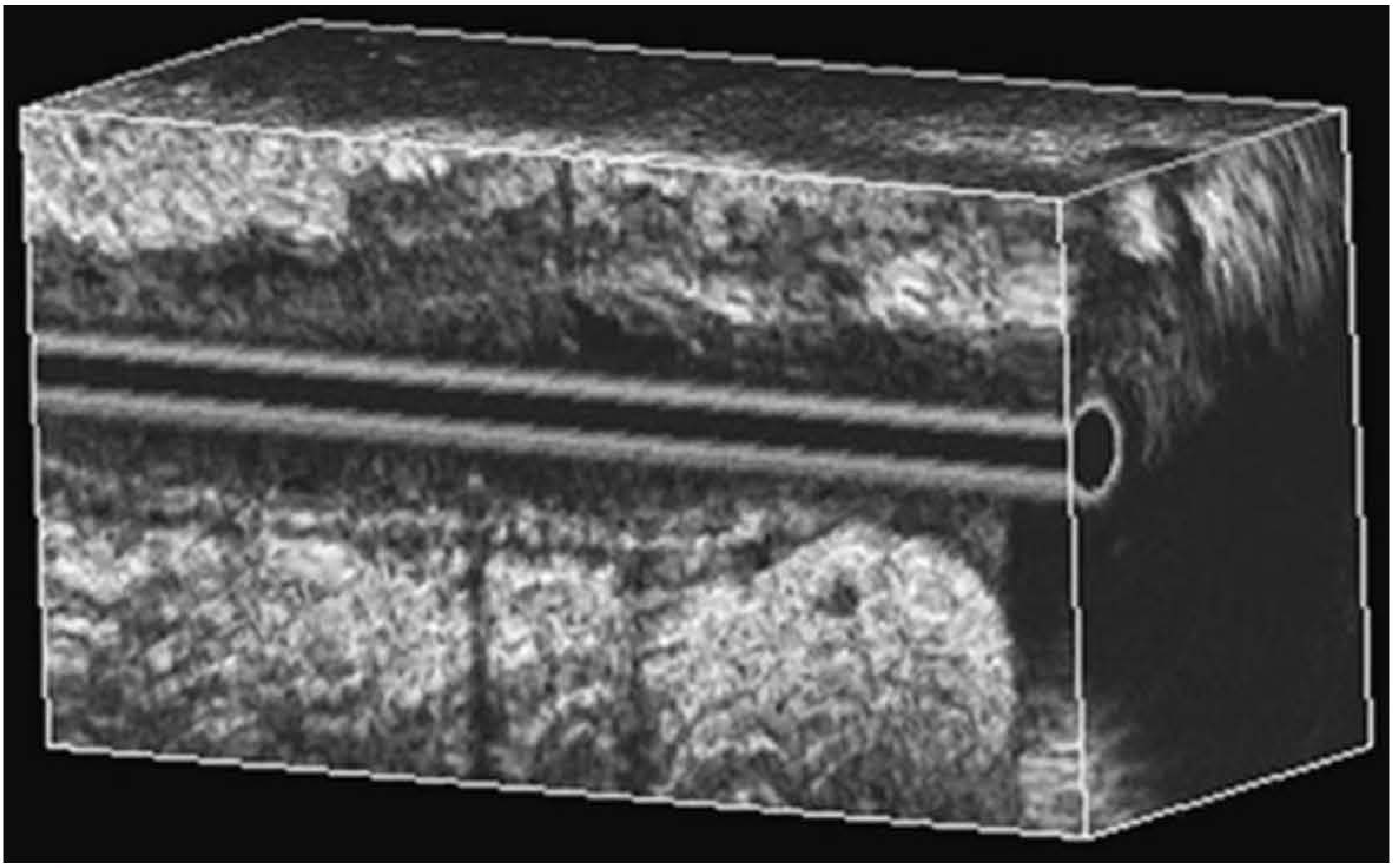

Figure 9.9 **Endoluminal ultrasonography – normal proximal ureter and UPJ.** (Source: With permission from Liu.)

The preoperative imagistic assessment of the stenosed ureteral segment is very important. The location and length of the stricture must be determined in order to establish the optimal modality for surgical approach (Fig. 9.10). In some cases, intravenous urography may be sufficient. Antegrade ureteropyelography (via the nephrostomy tube, when it exists) usually provides very correct information regarding the stenosed segment. Antegrade and retrograde combined ureteropyelography may be performed preoperatively or at the moment of the intervention.

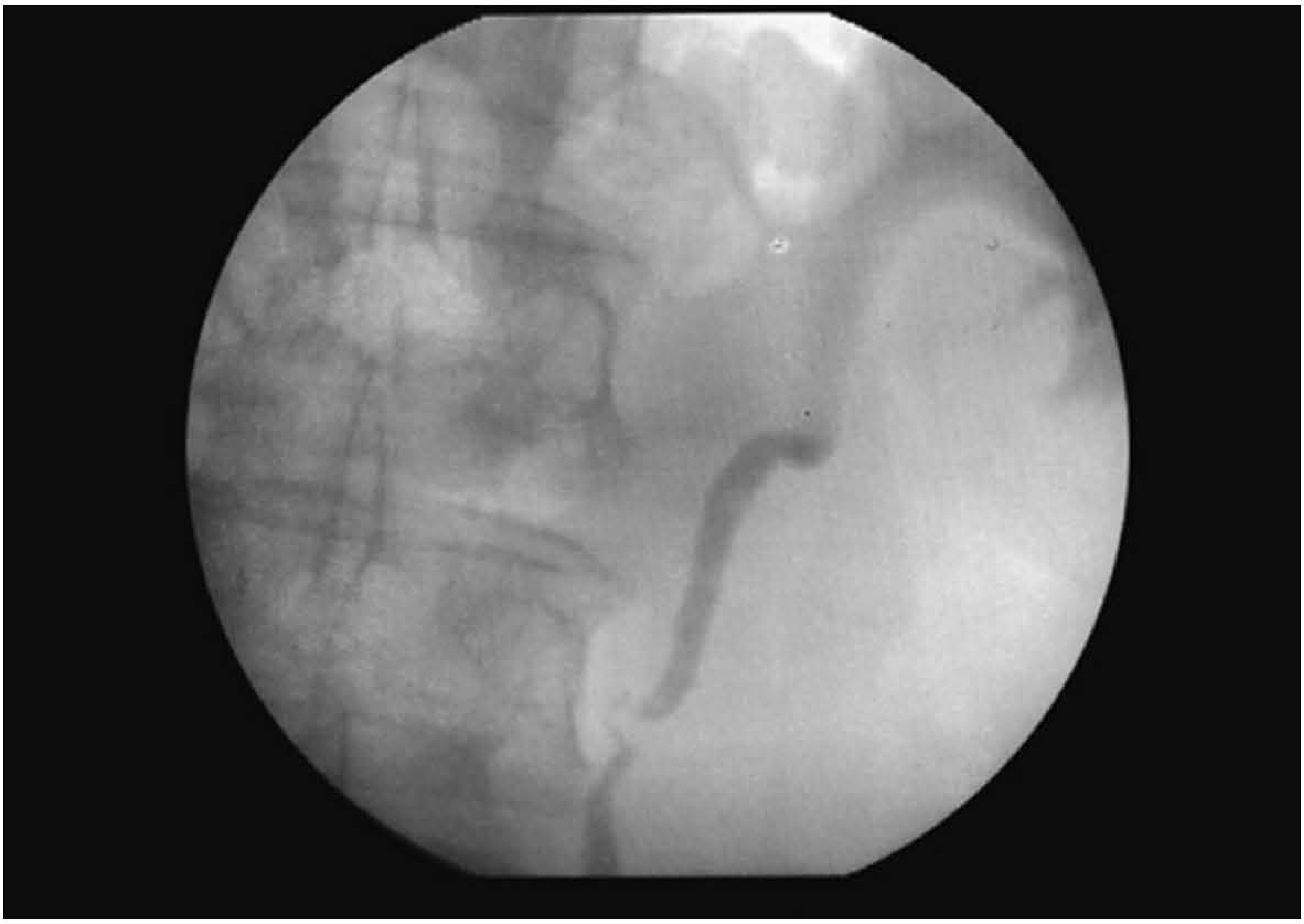

Figure 9.10 **Left ureteral stenosis – intraoperative fluoroscopy.**

In patients with pyelonephritis or altered renal function, the management of the patient should start with an adequate drainage through percutaneous nephrostomy or by placing a ureteral stent. This therapeutic gesture will allow for the optimization of the renal function. Preoperative drainage is unnecessary in patients with normal renal function and minimal obstruction. Antibiotic therapy of urinary tract infections is required preoperatively. Some authors recommend preoperative stenting of the stenosed segment with the purpose of passively dilating the ureter, thus facilitating the endoscopic approach (Eshghi and Lifson, 1995). However, this maneuver is not possible in case of complete ureteral obstruction.

9.3. Indications

All asymptomatic patients or those with obstruction consecutive to a benign ureteral stenosis have surgical indications with the purpose of preserving renal function.

The open surgical techniques used for the treatment of ureteral strictures (ureteroneocystostomy, kidney mobilization, Boari flap, transureteroureterostomy, intestinal interposition, kidney autotransplantation, nephrectomy) require abdominal interventions (some major) that are associated with high morbidity and with prolonged hospitalization and social reintegration.

The endoscopic alternatives are cold-knife incision, electrocautery incision (incision with a Collins loop), Acucise balloon, dilation balloon, and, relatively recently, the laser. Regarding the indications for using metallic ureteral stents, they are not yet fully systematized, most authors recommending placing this type of stent both in malignant and in benign ureteral stenoses.

The indications for the ureteroscopic approach of ureteral stenoses are represented by the following:

- benign inflammatory ureteral stenoses
- iatrogenic ureteral stenoses
- ureteral stenoses under

9.4. Instruments

A wide variety of instruments can be used for the endoscopic management of ureteral strictures, depending on the therapeutic alternative chosen.

Balloon catheters (with high pressure) are available in a wide range of dimensions (Fig. 9.11): diameters between 4 mm and 8 mm (after inflation) and lengths of 5–10 cm. Many of these are designed to support pressures from 12 atm to 20 atm, which is more than enough for most ureteral strictures.

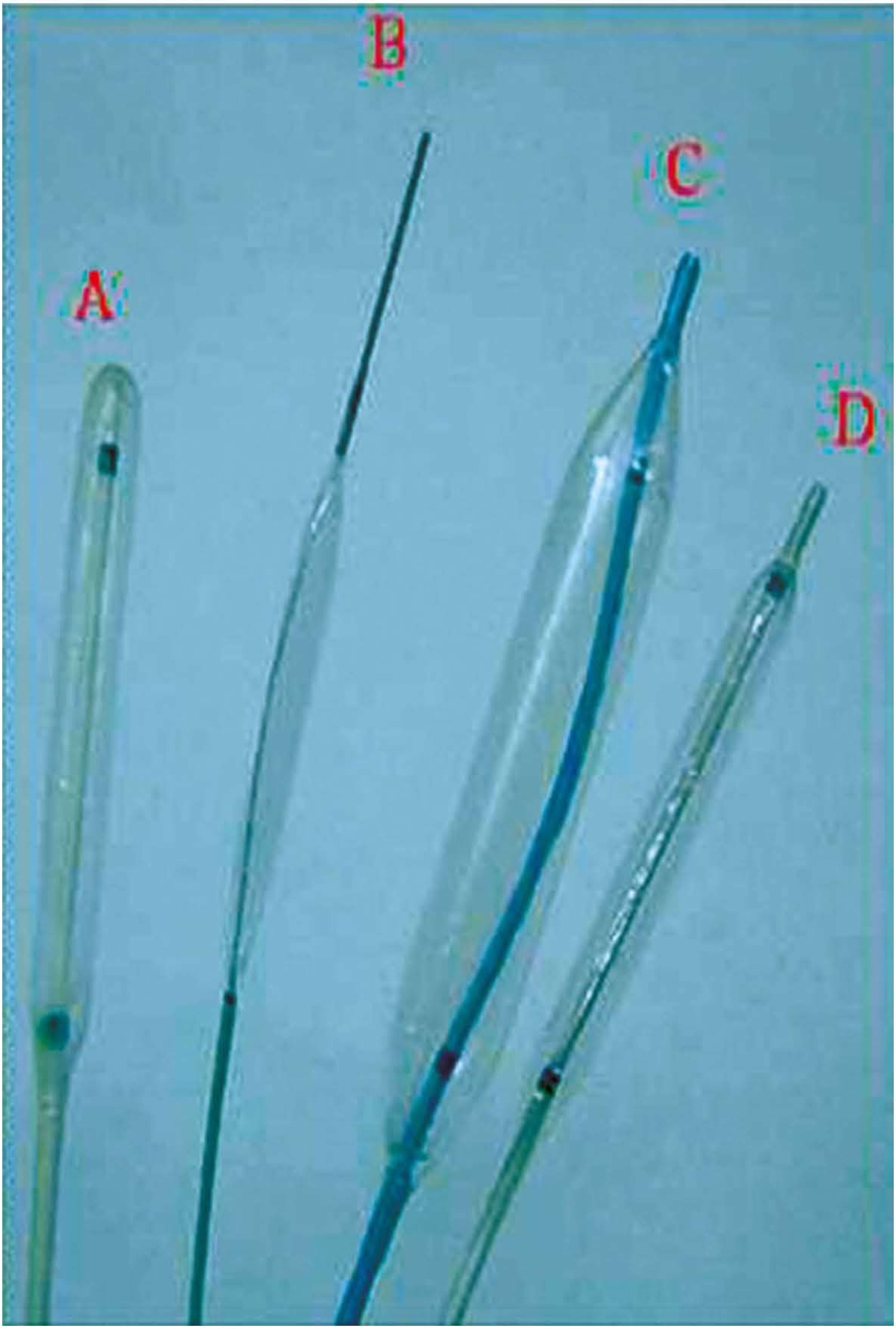

Figure 9.11 **Different types of balloon dilation catheters.**

The Acucise RP 35 device represents a balloon catheter (with low pressure: 1 atm) with a diameter of 10 F, which may reach 24 F after inflation. The catheter has a diameter of 6 F, which ensures an easy intraoperative access, without requiring preoperative stenting. An electrocautery fiber with a diameter of 150 µm and a length of 3 cm is fixed along the balloon's surface. This allows for simultaneously achieving balloon dilation and incision.

Cold-knife incision of the stricture requires using a rigid ureteroresectoscope of 11–13 F (Fig. 9.12). The incision knives are available in different configurations: straight, half-moon, or hook. Knives that slide on a metallic guidewire can be used, allowing for a better control of the incision, especially above the stenosis area.

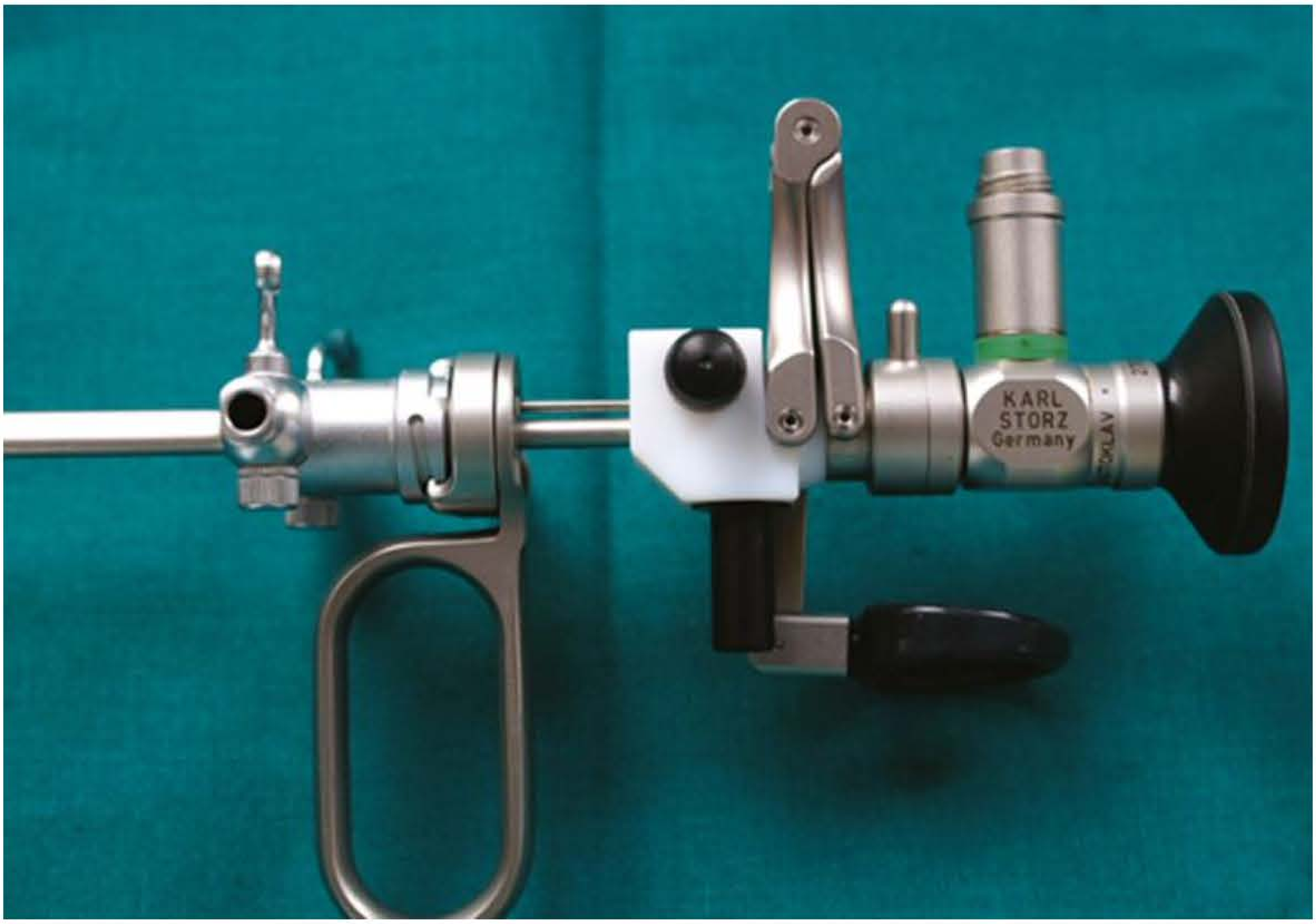

Figure 9.12 **Ureteroresectoscope.**

Incision with the electrocautery is achieved with Hubert-type electrodes (Cook Urological, Spencer, IN, USA) or with the Rite cutting device (ACMI Corporation, Southborough, MA, USA). The Rite type instrument has a low caliber (3 F), allowing its insertion through the flexible ureteroscope. The possibility of rotating the tip during the intervention allows for very good control of the incision.

The Nd:YAG and Ho:YAG lasers (Fig. 9.13) can also be used efficiently for the incision of ureteral strictures (Bagley and Erhard, 1995).

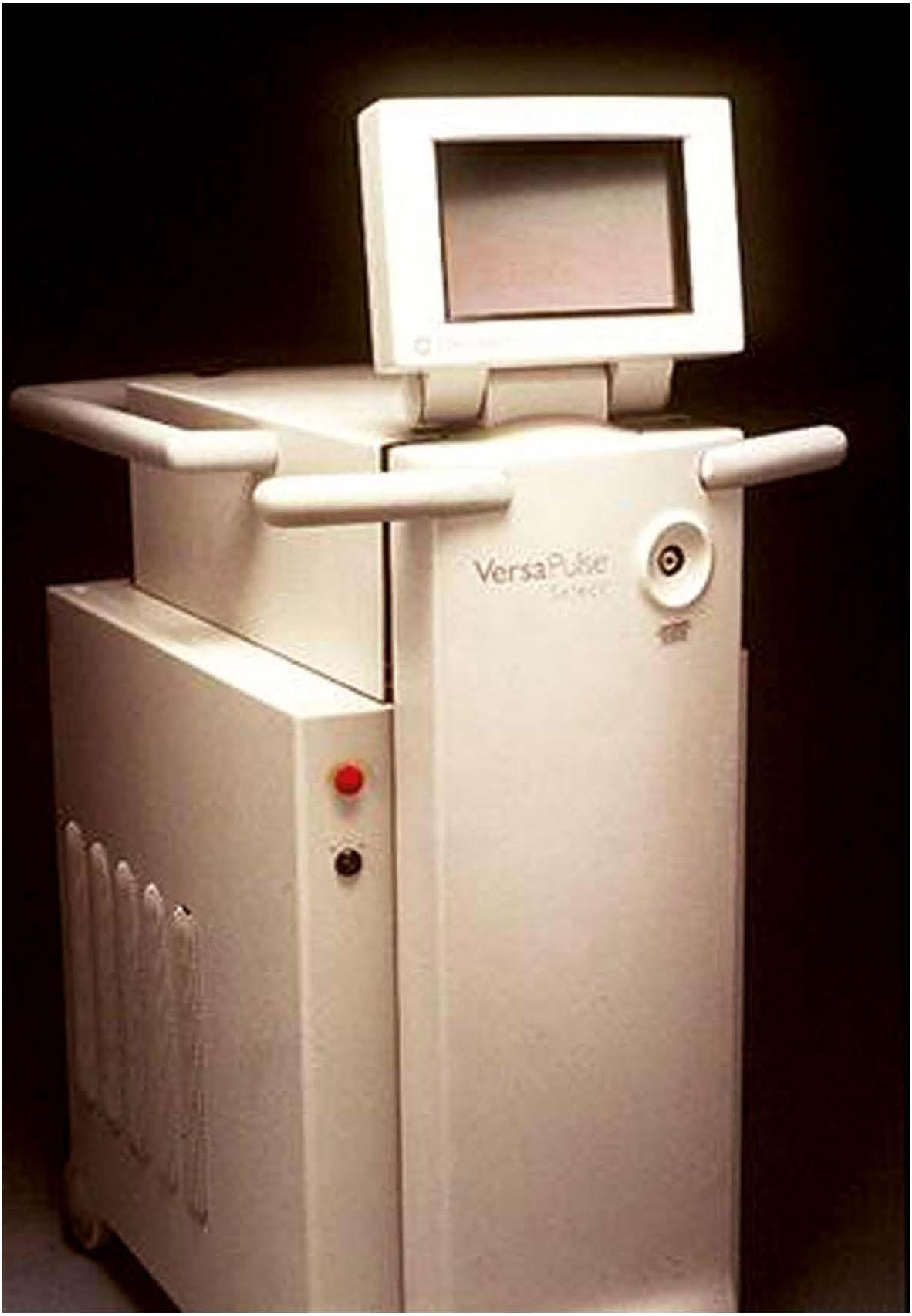

Figure 9.13 **Holmium:YAG laser.**

Energy can be transmitted through 200 and 365 μm fibers, inserted both through rigid and through flexible ureteroscopes.

Most authors consider that using a low power of the laser (25 W) is sufficient for the successful incision of strictures and for preventing complications secondary to injury of the neighboring structures (Kourambas et al., 2001).

9.5. Notions of operative technique

The development of endourological alternatives in the management of ureteral strictures was based on studies conducted by Davis on animals in 1943. He demonstrated that epithelialization of a ureteral stenosis stented with a JJ catheter occurs in 7 days. Muscular regeneration is complete at 6 weeks after the procedure (Davis et al., 1948).

Most authors agree with the fact that the success rate of endourological techniques is lower compared to open surgery. However, endourological approach is preferred due to its low morbidity, its reduced operative time and hospitalization period, and its costs. Moreover, the failure of minimally invasive techniques does not influence the prognosis if subsequent open surgery is required.

The main endourological alternatives for the management of ureteral strictures are as follows:

- balloon dilation
- endoureterotomy
- metallic stents

9.5.1. Balloon Dilation

Since the introduction of transluminal balloon dilation as a therapeutic alternative in arterial coronary disease (Grüntzig, 1978), this method has been used by many authors for the ureteral dilation of benign strictures. It represents the least traumatic modality of endoscopic approach and, at the same time, it constitutes a reasonable initial option.

The technique consists of four operative steps:

1. access to the upper urinary tract
2. placement of the dilation balloon at the level of the stricture
3. inflation of the balloon
4. insertion of the ureteral stent

Fluoroscopic control is essential for the correct positioning and for the adequate inflation of the balloon (Fig. 9.14).

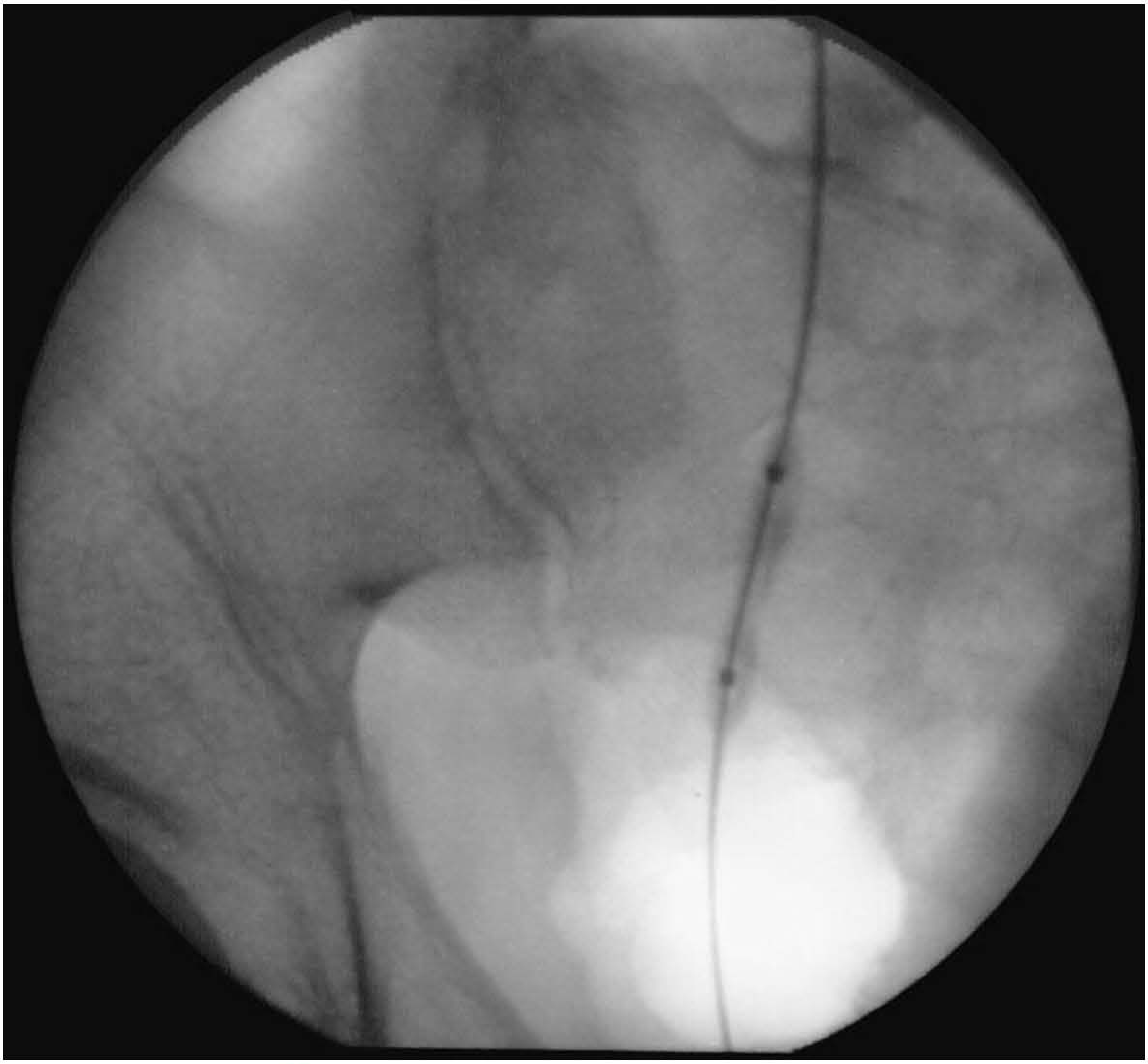

Figure 9.14 Balloon dilation of a pelvic ureteral stricture.

There are many studies in the literature regarding the efficiency of this method according to the slow or rapid dilation of ureteral strictures. Thus, Clayman experimentally studied the two techniques in pigs, dilating the distal ureter to 24 F and demonstrating that both procedures present the same safety profile (Clayman and Picus, 1988). The slow dilation, over a period of over 10 min, determines a lower residual inflammatory process at 6 weeks compared to rapid dilation. However, epithelialization of the denuded area, immediate inflammation, and submucous bleeding are similar in both groups immediately after the procedure (Clayman et al., 1987).

The effects of balloon dilation on the dynamics of the upper urinary tract and on the ureteral wall's morphology were studied by Selmy et al. (1993), who noted the presence of circumferential edema in the lamina propria, which extends into the muscularis, a fact that is responsible for the obstructive modifications detected by urodynamics. Progressive resorption of the pathological inflammatory modifications, reduction of the obstruction, and the normalization of the ureter's radiological aspect occur after a period of 6 weeks. The recommendations for maintaining an internal ureteral drainage with the JJ catheter for a period of 6 weeks were based on these observations.

Several authors have reported favorable results regarding the balloon dilation of ureteral strictures. The success rates are variable, between 48% and 88%, with an average of 55% (Table 9.1).

Table 9.1

The Results of Balloon Dilation for Ureteral Strictures

Author	Number of cases	Success rate (%)	Follow-up (months)

Banner and Pollack (1984)	44	48	–
Chang et al. (1987)	11	82	10
Johnson et al. (1987)	24	63	21
Lang and Glorioso (1988)	127	50	–
O'Brien et al. (1988)	17	60	17
Kramolowsky et al. (1989)	14	64	22
Netto et al. (2000)	19	58	24
Beckman et al. (2003)	17	76	15

However, there is no consensus regarding the optimal dimension of the dilation balloon and the most efficient technique (rapid or slow dilatation). Balloons between 4 mm and 10 mm are generally used, the number of inflation cycles varying from 1 to 10, while the duration of inflation is between 30 s and 10 min. There are also controversies regarding both the optimal dimension of the stent (between 6 F and 16 F) and the duration of maintaining it after the procedure (2 days to 12 weeks). In general, the success rate of balloon dilation for benign strictures is lower compared to that after endoureterotomy, and sometimes several procedures are necessary for obtaining the desired result (Fig. 9.15). Most authors agree that the main indication for balloon dilation is represented by nonischemic, very short strictures.

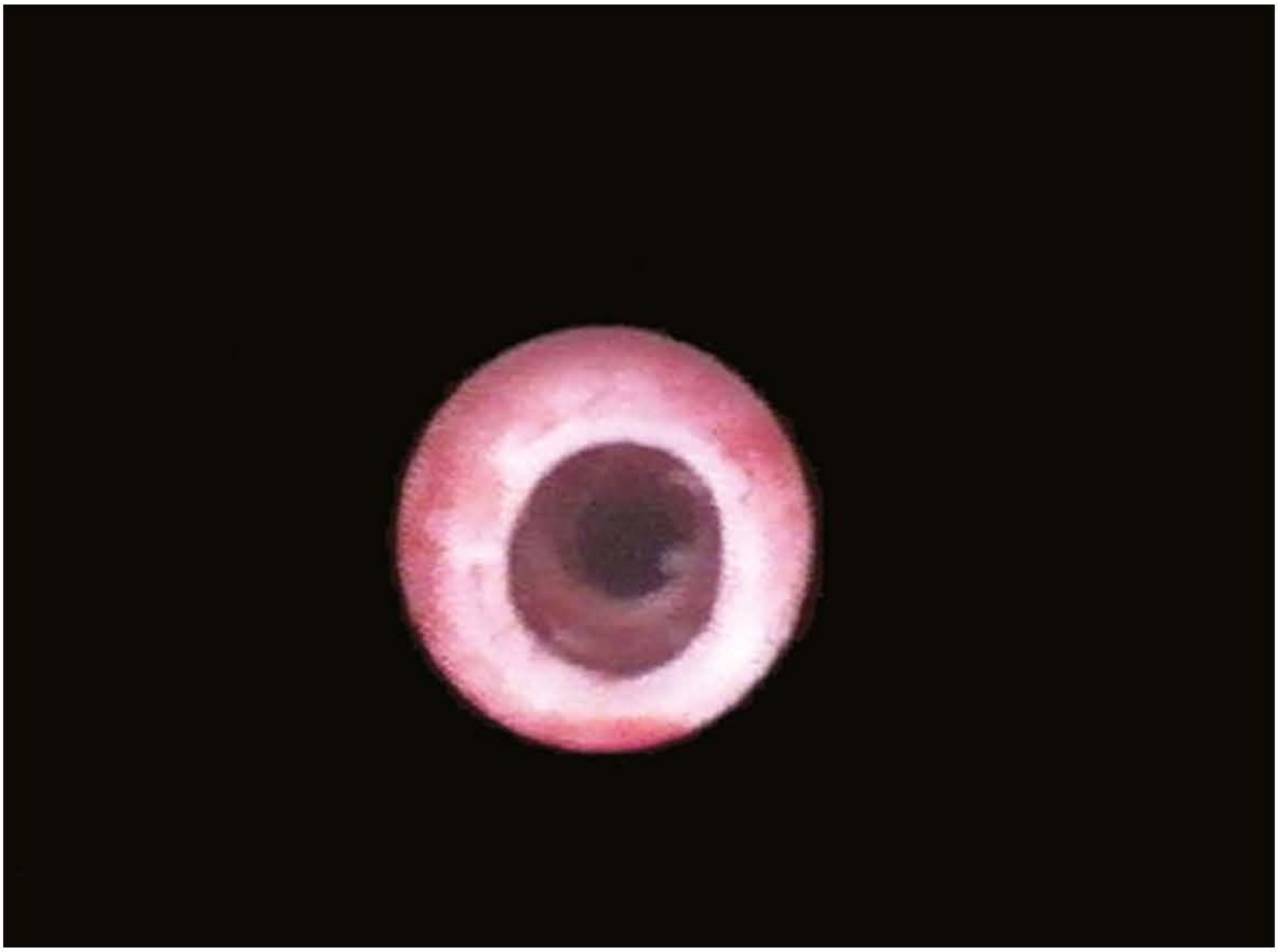

Figure 9.15 **Recurrence of a stricture after balloon dilation.**

Few complications are described in the literature for this technique, the most frequent being the dilation balloon's rupture. However, unlike the balloons used in the past, which were made of polyvinyl (with a high risk of tearing), the modern ones are made of reinforced polyethylene, significantly reducing the rate of intraoperative complications.

9.5.2.. Endoureterotomy

The development of small-caliber semirigid ureteroscopes (7.5 F) and of flexible ones, as well as of accessory instruments, has allowed the safe access of the upper urinary tract. The incision modalities for ureteral stenoses include cold knife, electrocautery, laser (Nd:YAG and Ho:YAG), and the Acucise balloon.

The approach of ureteral stenoses can be antegrade, retrograde, or combined.

9.5.2.1. Antegrade Approach

Antegrade percutaneous approach is generally reserved for the treatment of proximal ureteral stenoses, in patients who also present an associated renal condition (calculi) (Wickham, 1983). In order to gain access to the stenosed area with the semirigid instrument, it is recommended that the percutaneous pathway be done through the upper or middle calyx. Most authors recommend posterior or posterolateral incision of the strictured area, until the retroperitoneal fat is visualized (Fig. 9.16) (Badlani et al., 1986). In order to achieve optimal results, the incision must start at the renal pelvis and extend approximately 1 cm caudal to the stenosed area.

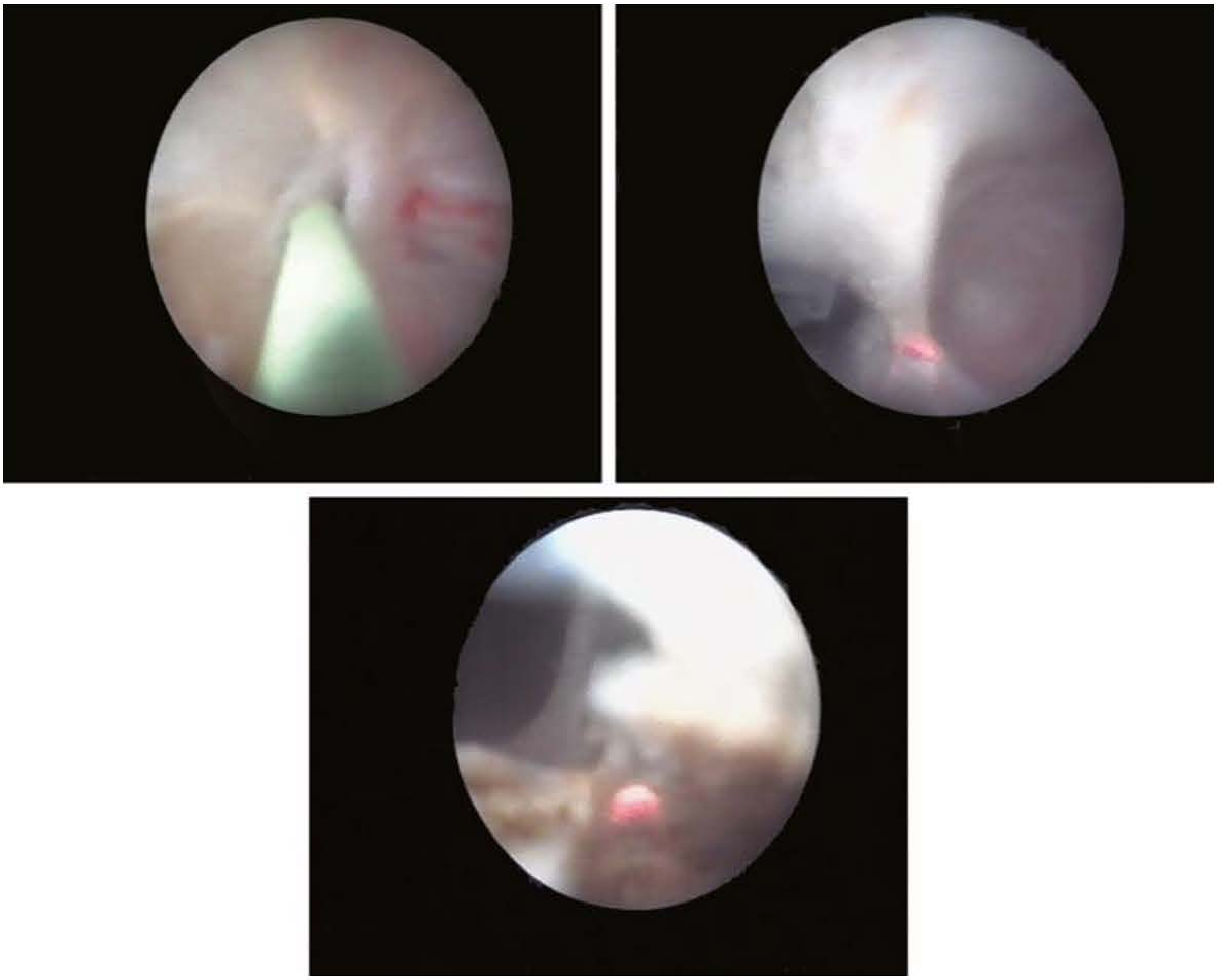

Figure 9.16 **Antegrade endoureterotomy with Nd:YAG laser.**

Stenoses located in the middle ureteral segment can be approached antegradely or retrogradely. The antegrade approach is identical to that previously described, the only difference being that at the cephalic extremity of the stenosis, the incision will be extended 1 cm proximally into healthy ureteral tissue (up to the vicinity of the ureteropelvic junction). For strictures located in the vicinity of the iliac vessels, it is recommended that a flexible ureteroscope be used (Fig. 9.17), which requires using electrocautery probes (2–3 F) or laser probes (200 or 400 µm).

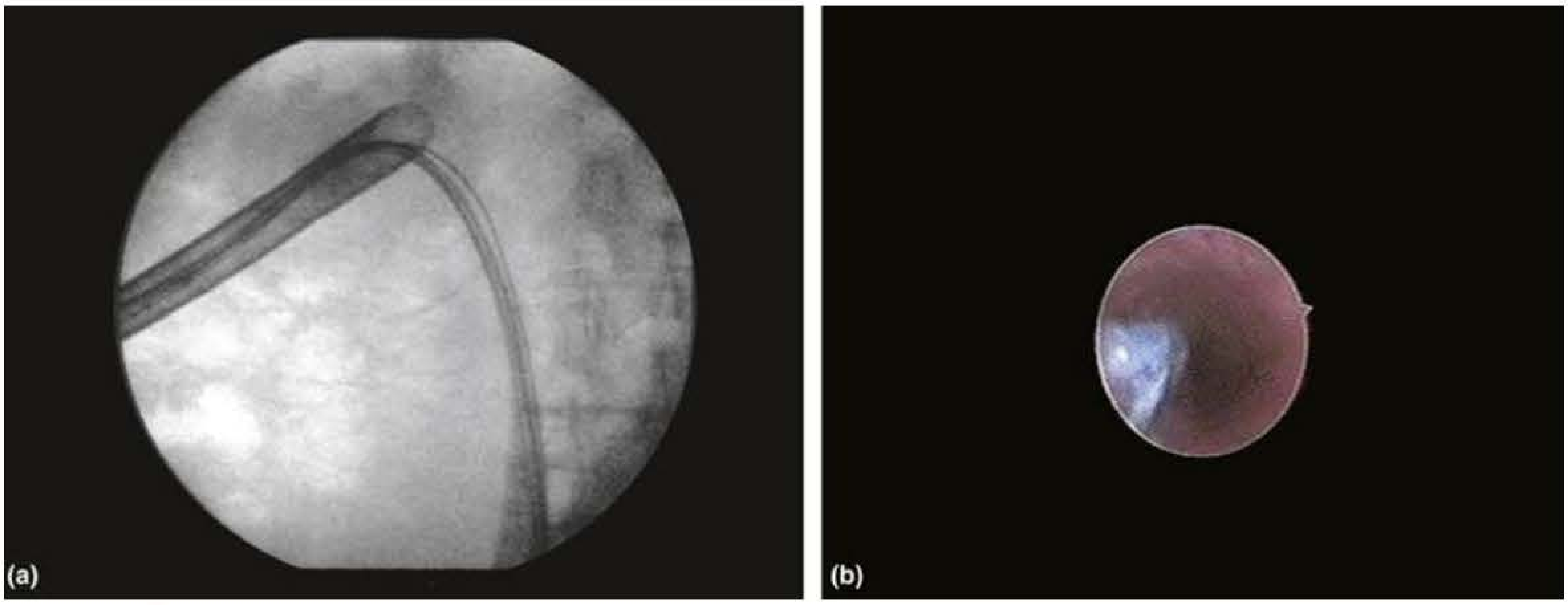

Figure 9.17 **Antegrade approach of a middle ureteral stricture using the flexible ureteroscope.** (a) Fluoroscopic and (b) intraoperative aspect.

The use of direct visual approach under fluoroscopic control in two planes provides a better intraoperative orientation. The incisions are made laterally for proximal ureteral strictures (located above the iliac vessels), anteriorly for those located at the level of the iliac vessels (10 o'clock on the right, respectively 2 o'clock on the left), and anteromedially for those located below this level. Pelvic ureteral stenoses located in the vicinity of the uterine artery in women or of the vas deferens in men will be incised posteriorly at 6 o'clock. In all cases, the incision must be extended 1 cm proximal and distal to the stricture, with exposure of the periureteral fat. In patients with very tight strictures, initial balloon dilation may be necessary in order to allow for a correct incision (Dierks, 1990).

9.5.2.2. Retrograde Approach

The choice of a retrograde or antegrade approach is made according to the particularities of the case and to the surgeon's preference. However, the low morbidity rate, the reduced hospitalization period, and the ease of retrograde access to the upper urinary tract represent elements that recommend retrograde approach as the first-line alternative for most patients with ureteral strictures (Geavlete et al., 2000a, b, c).

Most frequently, retrograde approach is used for the treatment of distal ureteral strictures. Sometimes, these may be located at the level of the ureteral orifice, of the intramural ureter, or in the proximity of the uretero-vesical junction. In these cases, the incision should be extended up to the ureteral orifice (Yamada et al., 1995). A ureteroresectoscope can be used, the incision being made at 12 o'clock, extended over a distance of approximately 1 cm beyond the stricture area, with Collins- or Orandi-type probes, the electrocautery being set at 50 W. Flexible or rigid instruments can be used for stenoses located at the level of the proximal ureter, the incision being made in the manner previously described.

The Acucise-type balloon can be used as a therapeutic alternative for proximal or distal ureteral stenoses (Cohen et al., 1996). The balloon is positioned under fluoroscopic control. There are a series of particularities regarding the modality of performing each type of incision according to the affected ureteral segment (Table 9.2, Figs 9.18–9.21).

Table 9.2

Indications for the Type of Incision According to the Ureteral Segment

Ureteral segment	Type of incision	Observations
Proximal and middle	Posterior (Fig. 9.19) or posterolateral	• From the renal pelvis to approximately 1 cm caudal to the stenosed area • Until the retroperitoneal fat is visualized
Above the iliac vessels	Lateral or posterolateral (Fig. 9.20)	• Incision extended 1 cm proximal and distal to the stricture, with exposure of the retroperitoneal or periureteral fat
At the level of the iliac vessels	Anterior (10 o'clock on the right, 2 o'clock on the left) (Fig. 9.21)	• Incision extended 1 cm proximal and distal to the stricture, with exposure of the retroperitoneal or periureteral fat

Below the iliac vessels	Anteromedial	• Incision extended 1 cm proximal and distal to the stricture, with exposure of the retroperitoneal or periureteral fat
At the level of the uterine artery or vas deferens	Posterior (6 o'clock)	• Incision extended 1 cm proximal and distal to the stricture, with exposure of the retroperitoneal or periureteral fat
Ureteral orifice	12 o'clock	• Incision extended over a distance of approximately 1 cm beyond the stricture area

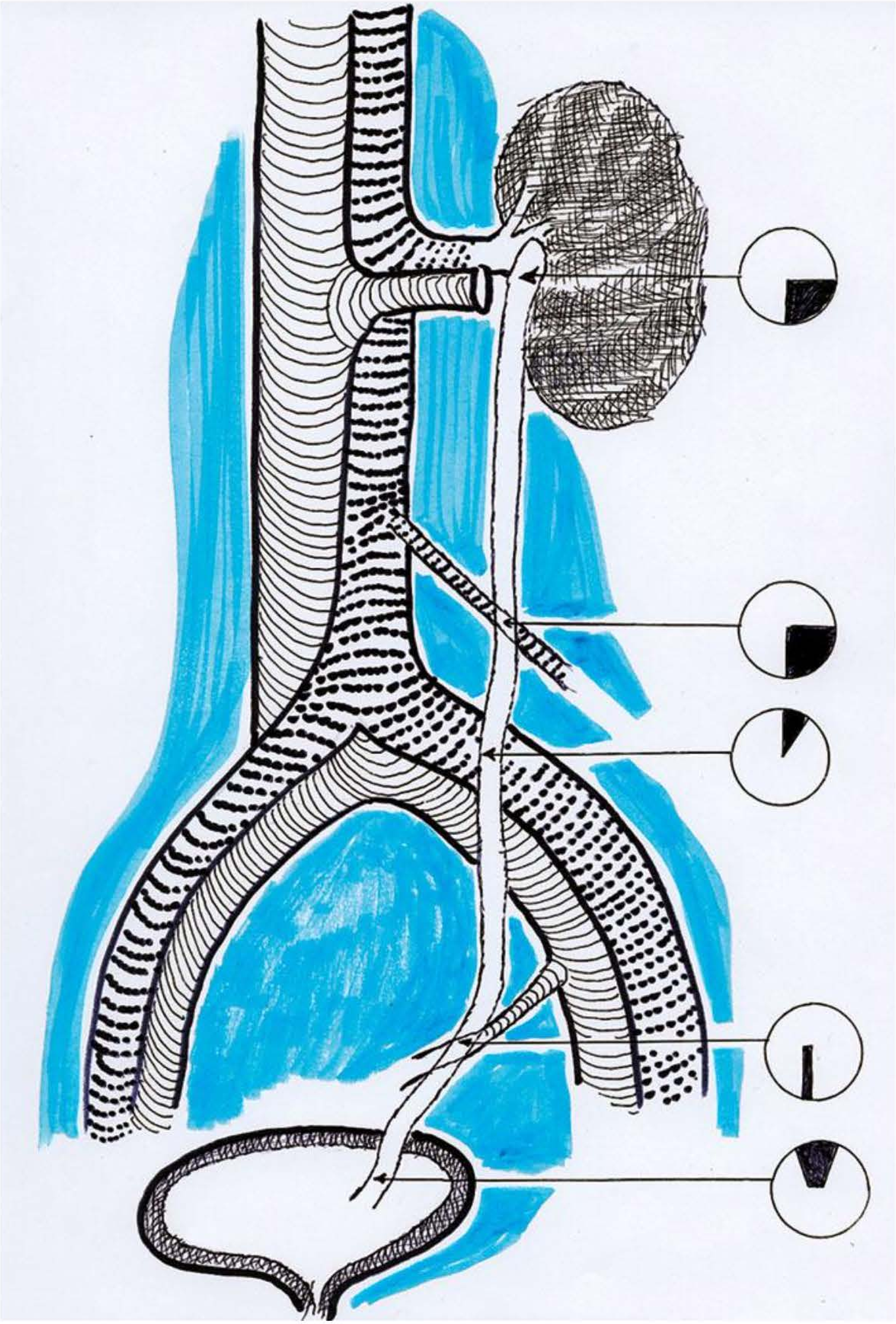

Figure 9.18 Schematic presentation of the different types of incision according to the stricture's location.

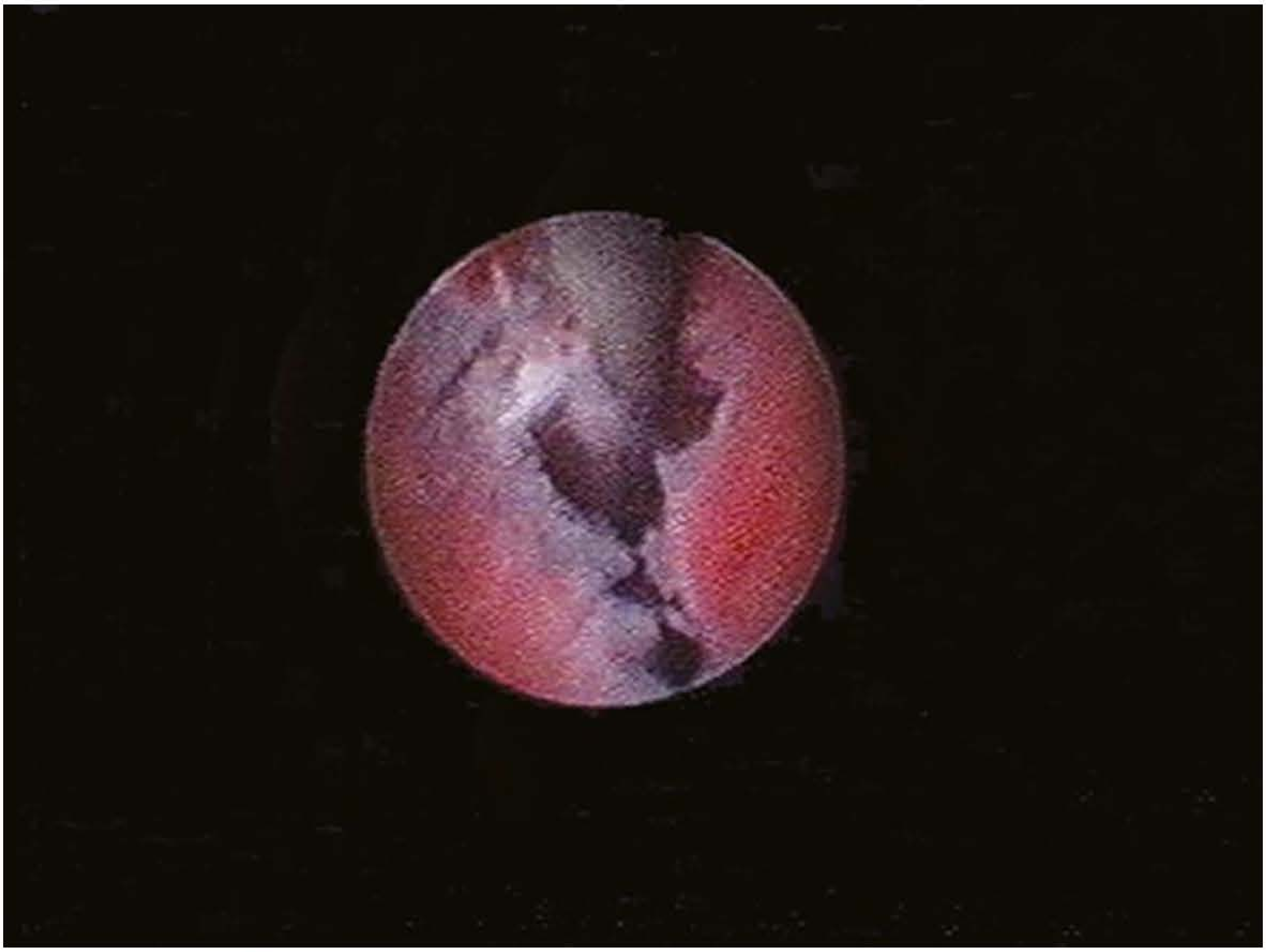

Figure 9.19 **Posterior incision for an upper lumbar ureteral stenosis.**

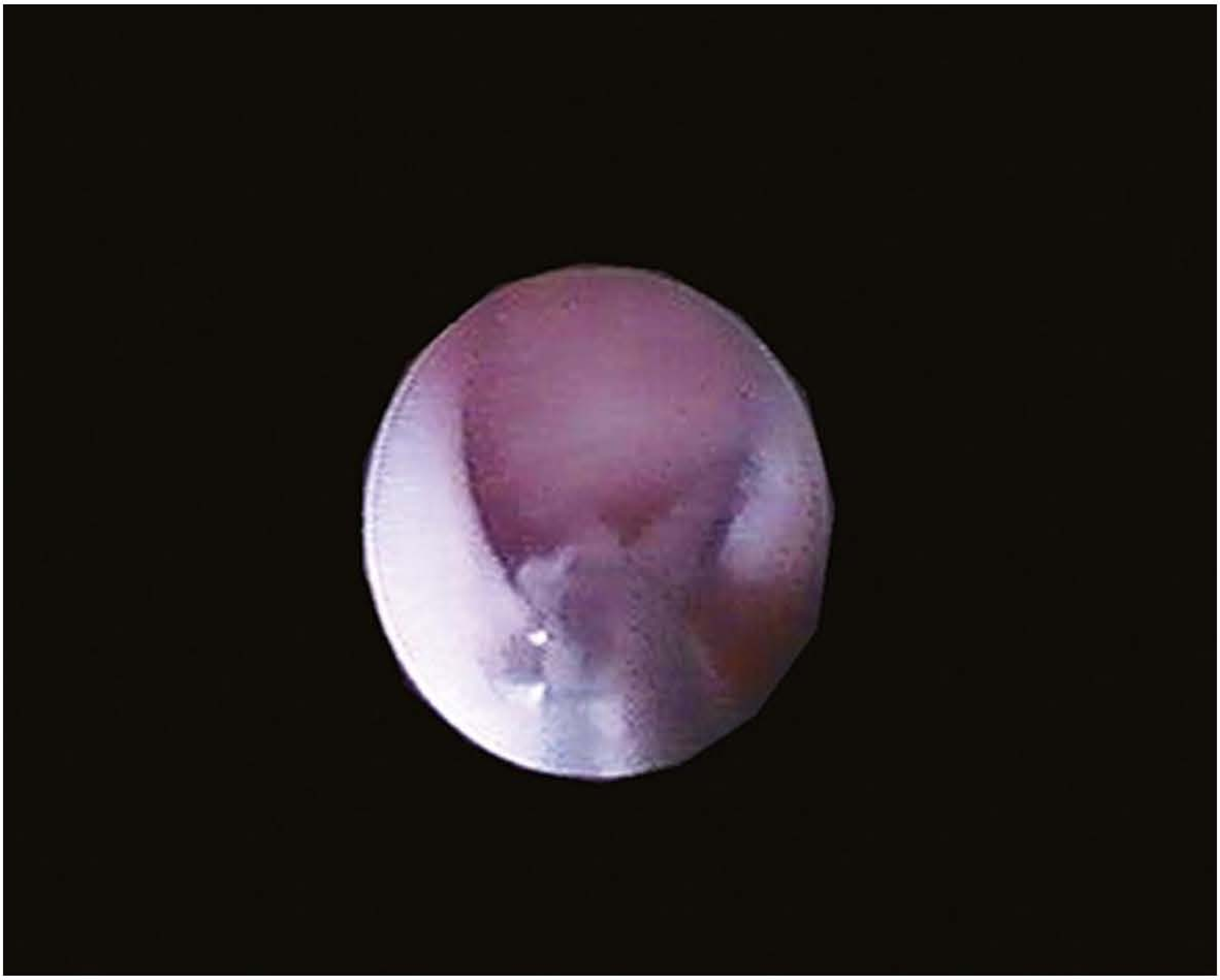

Figure 9.20 Posterolateral incision for a lower lumbar ureteral stenosis.

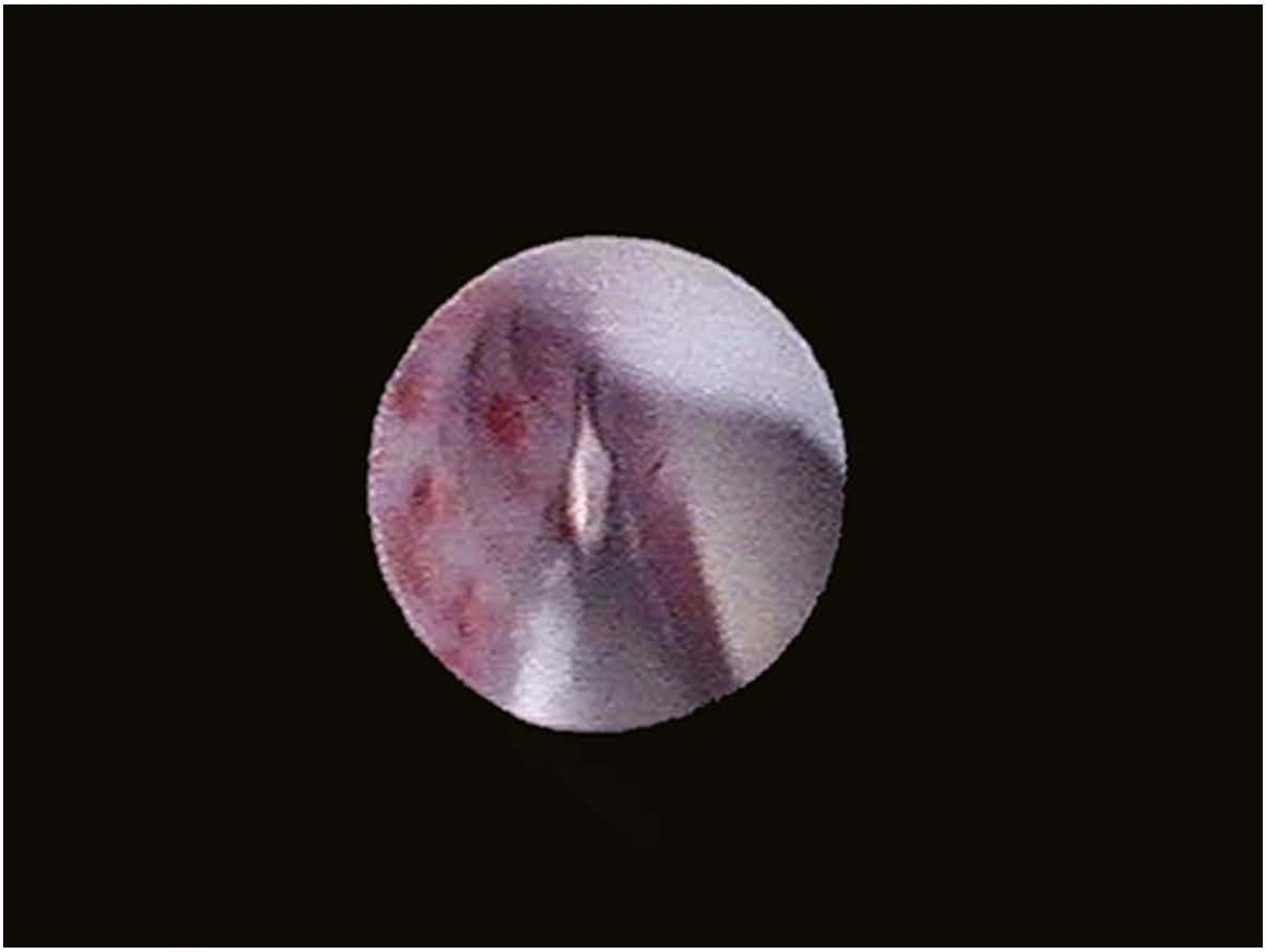

Figure 9.21 **Anterior incision for a ureteral stenosis at the level of the iliac vessels.**

At the level of the proximal ureter, above the iliac vessels, the electrocautery wire (which makes the incision) will be oriented posterolaterally, while below the iliac vessels it will be directed anteromedially in order to avoid the iliac artery and vein (which pass lateral to the ureter). For strictures located at the level of the iliac vessels, most authors recommend avoiding the use of the Acucise and to use ureteroscopic approach under visual control. In cases with uretero-vesical reimplantation, the incision of potential stenoses will be performed anterolaterally.

9.5.2.3. Combined Antegrade and Retrograde Approach

Complex ureteral strictures, especially those located at the level of a uretero-enteral anastomosis, frequently require a combined antegrade and retrograde approach (Fig. 9.22).

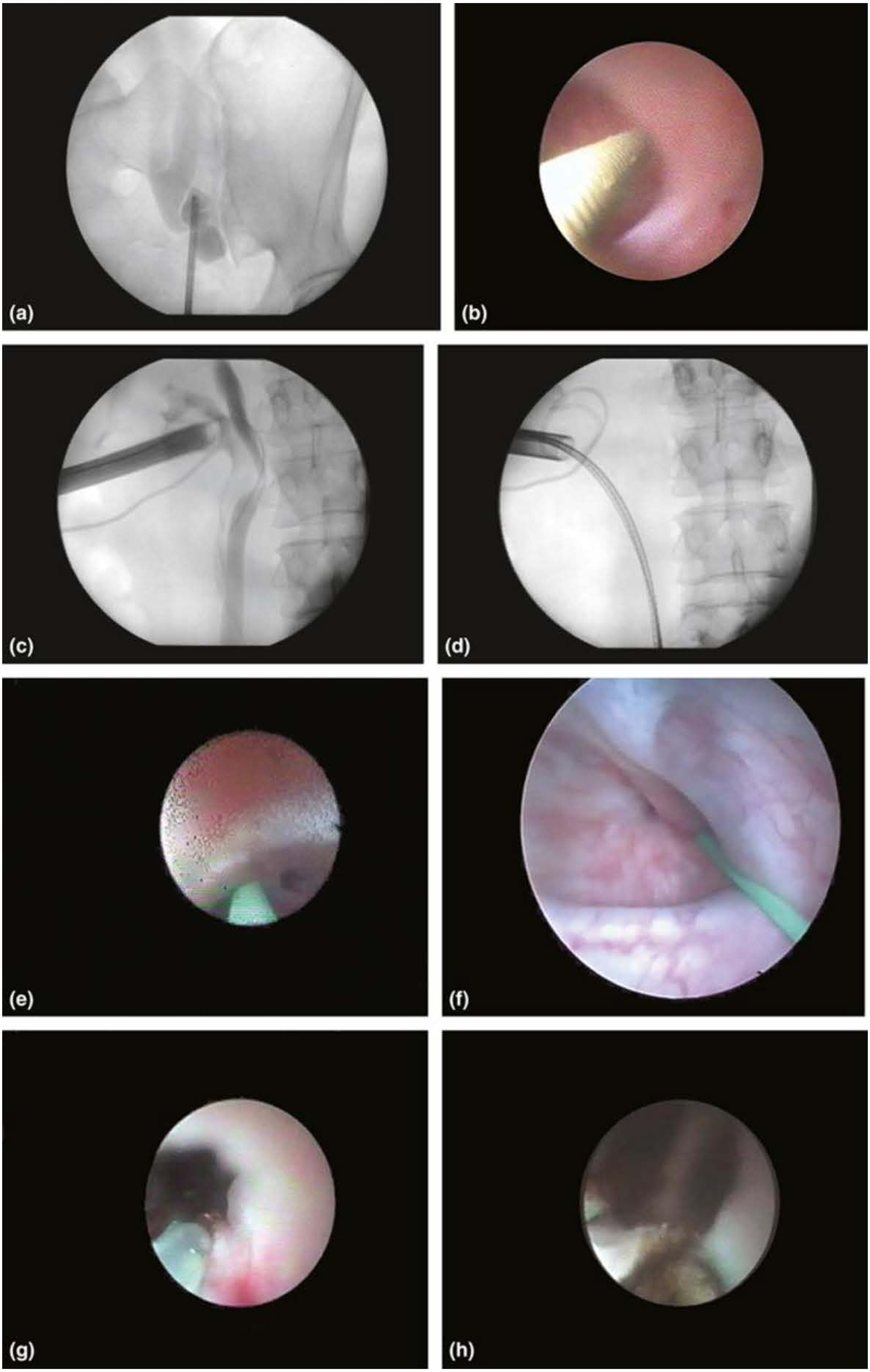
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)

Figure 9.22 **Combined antegrade and retrograde approach of a complete ureteral stenosis: initial fluoroscopic aspect with complete stopping of the contrast media (a), retrograde approach – complete ureteral stenosis (b), percutaneous approach (c), antegrade flexible ureteroscopy (d) with identification of the punctiform ureteral stenosis (e) and placement of a reinforced metallic guidewire, retrograde approach with laser incision of the ureteral stenosis (f, g), final postoperative aspect (h).**

The procedure allows for a rapid identification of the stenosed area, which is usually "hidden" between the urinary derivation's folds (which makes the approach only in a retrograde manner very difficult).

A particular situation is represented by complete ureteral strictures. In these cases, the extent of the stenosis area can be assessed by simultaneously performing a retrograde and an antegrade ureteropyelography (through the nephrostomy tube). For short strictures (1 cm), endoureterotomy using the "cut to the light" technique may be indicated (by inserting the ureteroscope antegradely, the incision being made retrogradely). Although some authors have reported good results even for strictures of up to 5 cm in length (Bagley, 1990; Conlin and Bagley, 1996), most of them recommend that complete ureteral stenoses longer than 2 cm be approached by open surgical procedures.

9.5.2.4. Operative Technique

The patient is placed in the lithotomy position for the standard retrograde intervention. If simultaneous antegrade and retrograde approach is necessary, it is recommended to position the patient in decubitus with the legs apart (split-leg prone position) (Nord et al., 1991) or, as an alternative, the patient can be placed in a dorsolithotomy position, lifting the flank with the affected ureter (by placing a role of textile material), thus allowing easier access to the nephrostomy area.

The first intraoperative step consists of radiologically detecting the stenosed ureteral segment. A retrograde ureteropyelography is performed for this purpose, followed by placement of a guidewire that must be ascended beyond the stricture; this can sometimes represent the most difficult moment of the intervention. Most authors recommend using hydrophilic guidewires. After placing the safety guidewire, the ureteroscope is ascended up to the level of the involved ureteral segment, with direct visual control in order to exclude other causes of ureteral obstruction (tumors or calculi) that could pass unobserved during the previous radiological explorations. If there are doubts regarding the etiology of the stricture, material can be collected for biopsy or for cytological examination before making the incision (Fig. 9.23).

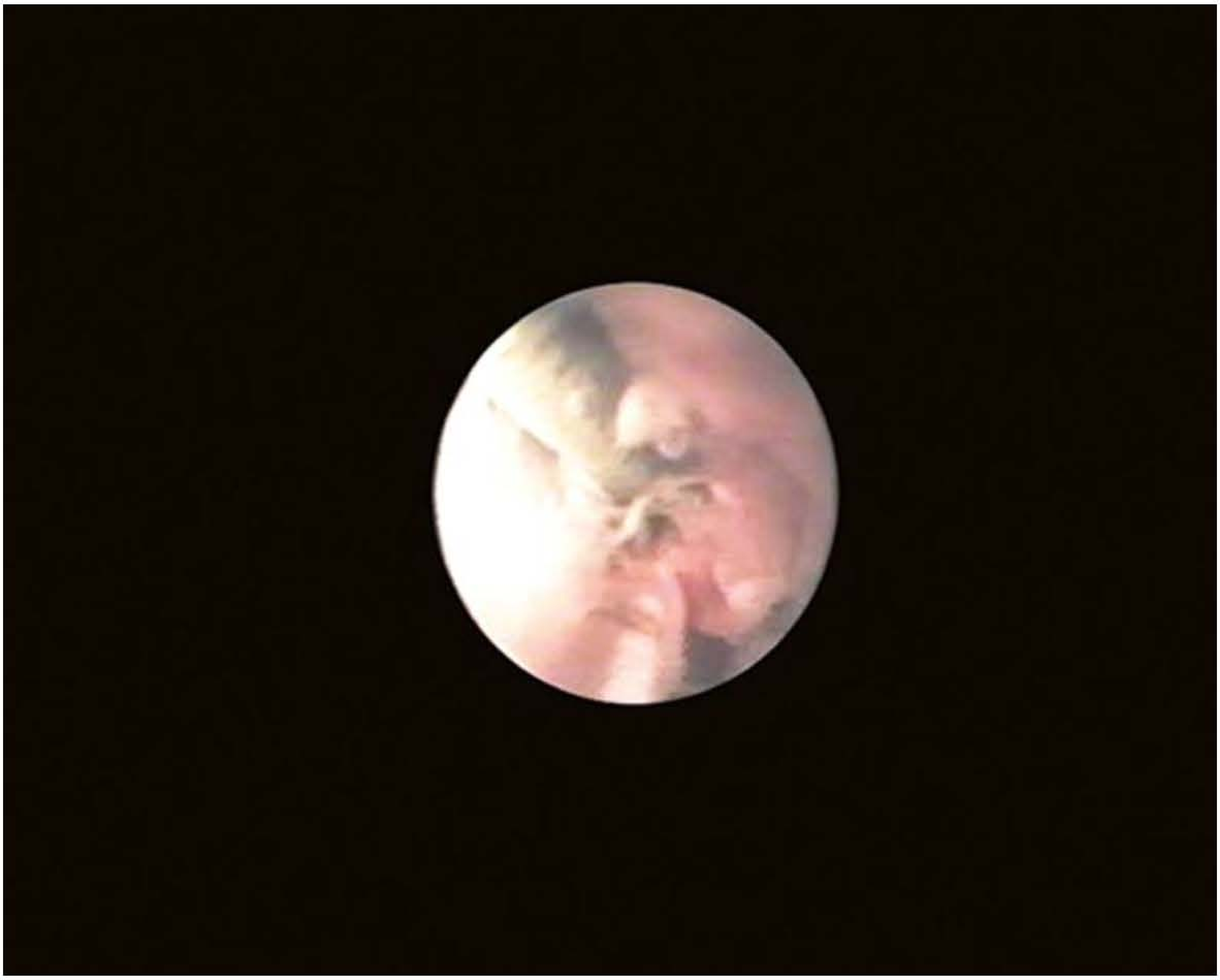

Figure 9.23 **Malignant ureteral stricture.**

Knowing the ureteral anatomy and the safest areas for making the incision (depending on the location of the obstruction) are very important elements for performing the intervention safely and with a low rate of complications. The use of intraoperative endoluminal ultrasonography offers the advantage of obtaining correct information regarding the periureteral structures, being extremely useful for choosing the safest incision area (Bagley et al., 1994).

If the electrocautery is used, the safety guidewire must be isolated with the help of a ureteral catheter or replaced with a special guidewire, such as a nitinol one coated with polyurethane. This can prevent transmission of the energy from the electrocautery to the other ureteral structures, which could cause undesired secondary lesions.

The incision can be made safely with a cold knife, with the electrocautery's probe, or with the holmium:YAG laser (Multescu et al., 2006). Cold-knife incision can prevent the development of tissular fibrosis consecutive to the intervention, with minimal secondary lesions (Fig. 9.24). The use of a flexible ureteroscope requires using the Rite electrode or a Ho:YAG laser.

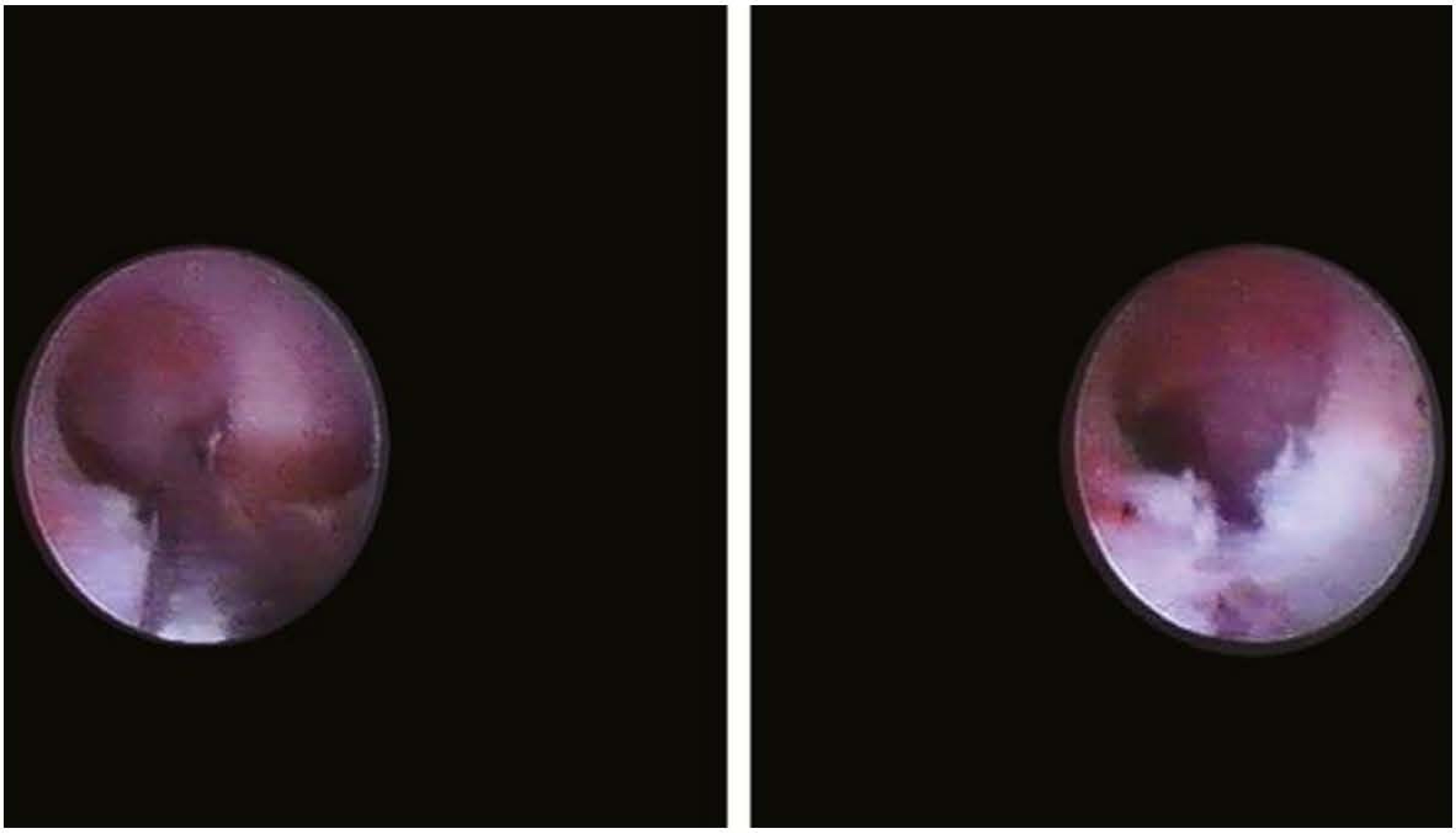

Figure 9.24 **Cold-knife incision until the periureteral fat is visualized.**

The ideal incision should penetrate the entire thickness of the ureteral wall, until the periureteral fat is visualized (Geavlete et al., 2002) (Fig. 9.25). However, when there is significant periureteral fibrosis, this goal becomes difficult or even impossible to achieve. In these situations, the incision is made deep enough to provide an adequate luminal diameter. Balloon dilation can be performed after the ureteroscopic incision, thus obtaining an additional enlargement of the stenosed area. The efficiency of the incision is checked by injecting contrast media (antegradely or retrogradely). Its leakage indicates the incision's efficiency.

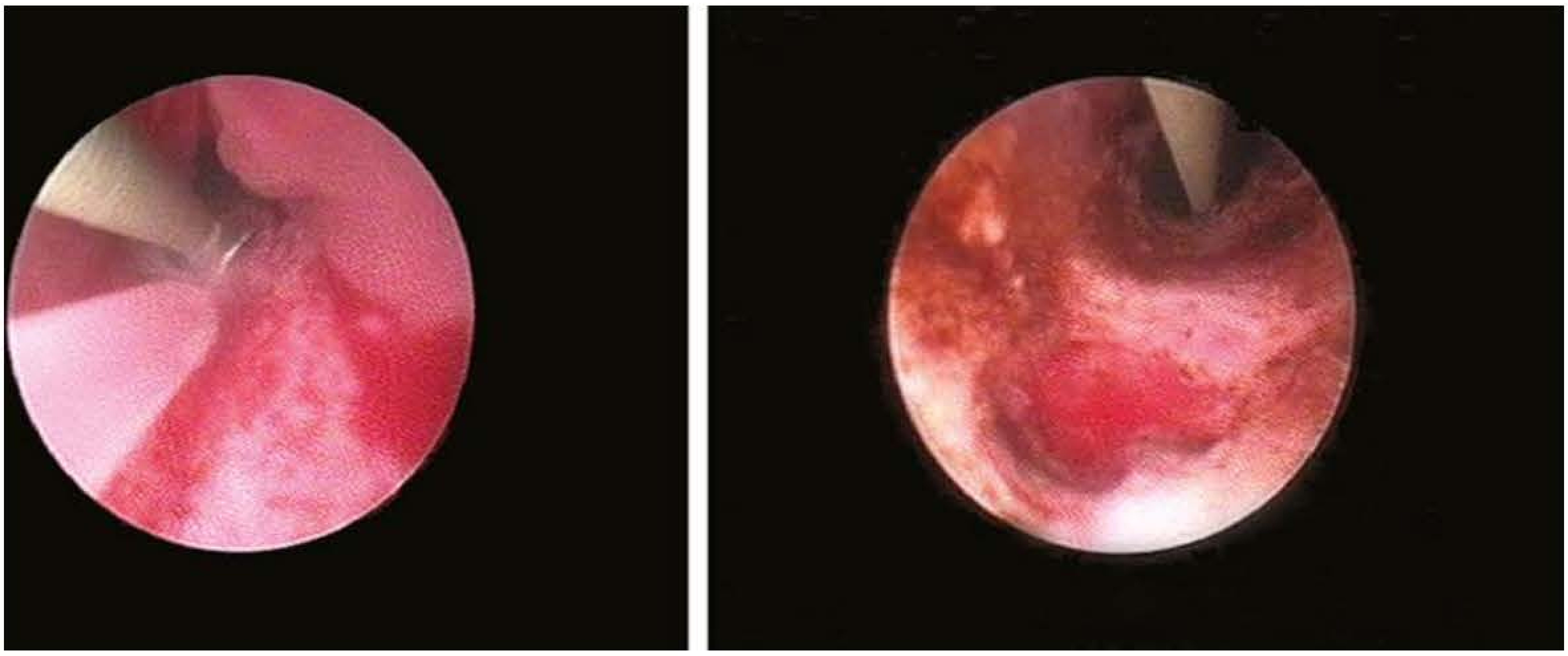

Figure 9.25 **Laser incision until the periureteral fat is visualized.**

Strictures that determine complete ureteral obstruction raise more difficult problems. Placing a safety guidewire along the stenosed ureteral segment represents the key element of the procedure with regard to its importance and degree of difficulty. If the segment is very short and the proximal and distal ends of the ureter are well aligned, the rigid tip of the guidewire can be used for "puncturing" the stricture under sonographic and fluoroscopic control. Stabilizing the guidewire with the help of a ureteral catheter can facilitate surpassing the stenosed area.

Longer strictures require an incision made under direct visual (ureteroscopic) control from one end of the obstructed segment to the other. This implies simultaneous retrograde and antegrade ureteroscopic approach (Fig. 9.26), using the "cut to the light" technique. With both tips of the ureteroscopes at the proximal and distal end of the stenosis

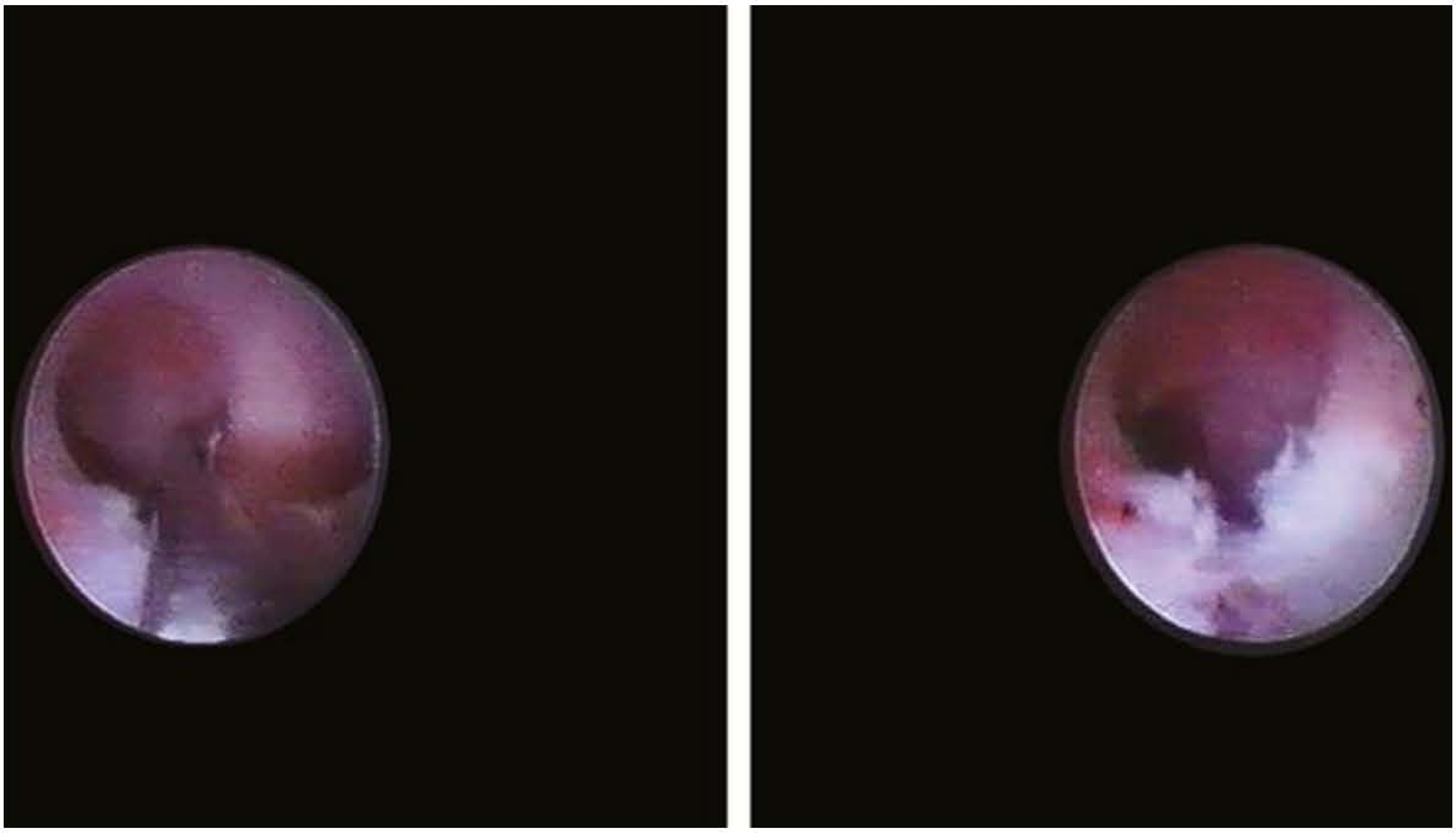

Figure 9.24 Cold-knife incision until the periureteral fat is visualized.

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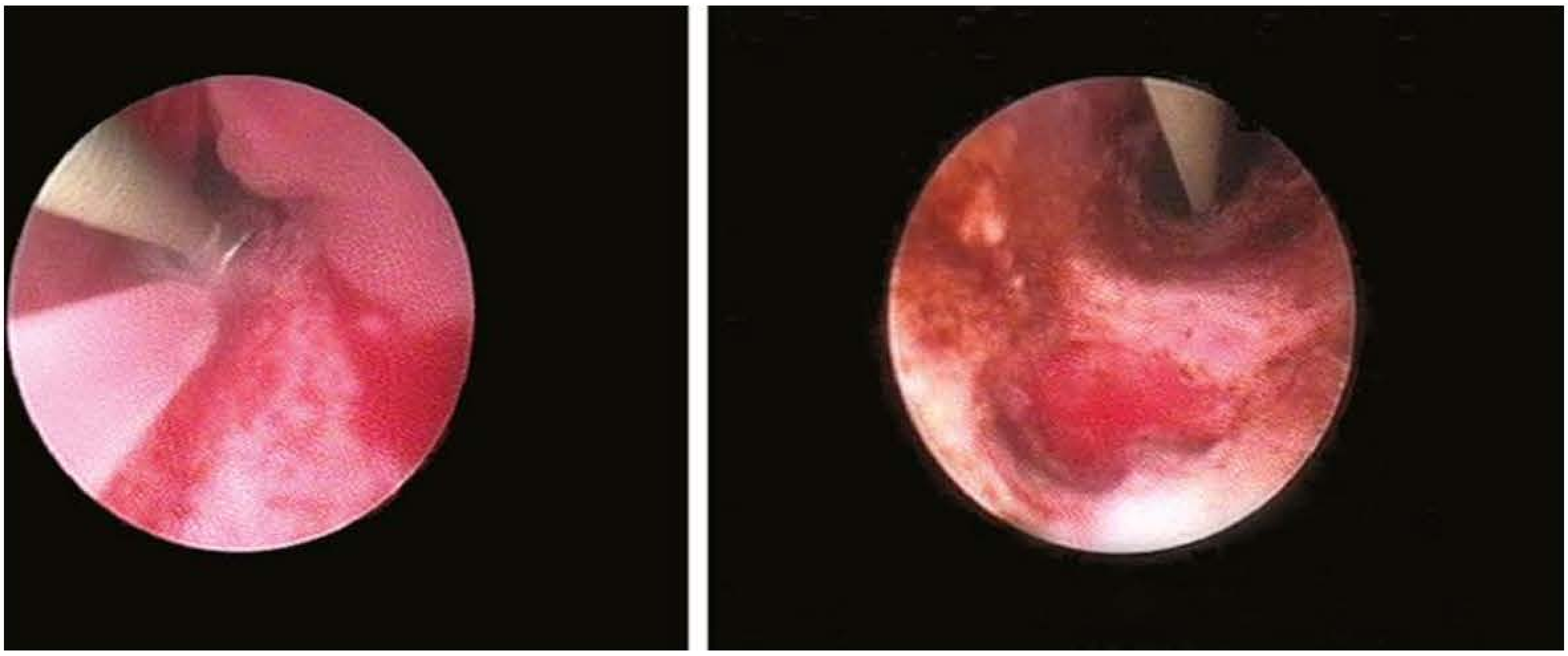

Figure 9.25 Laser incision until the periureteral fat is visualized.

Strictures that determine complete ureteral obstruction raise more difficult problems. Placing a safety guidewire along the stenosed ureteral segment represents the key element of the procedure with regard to its importance and degree of difficulty. If the segment is very short and the proximal and distal ends of the ureter are well aligned, the rigid tip of the guidewire can be used for "puncturing" the stricture under sonographic and fluoroscopic control. Stabilizing the guidewire with the help of a ureteral catheter can facilitate surpassing the stenosed area.

Longer strictures require an incision made under direct visual (ureteroscopic) control from one end of the obstructed segment to the other. This implies simultaneous retrograde and antegrade ureteroscopic approach (Fig. 9.26), using the "cut to the light" technique. With both tips of the ureteroscopes at the proximal and distal end of the stenosis respectively, these are aligned in the first step under fluoroscopic control in two planes. The light source of the working ureteroscope is subsequently turned off, in order to locate the opposite end of the stricture by visualizing the light of the secondary ureteroscope. The incision can be made with the electrocautery or the Ho:YAG laser, aiming to establish ureteral continuity (Thomas et al., 2003). In order to safely perform the operative procedure, the guidewire must be maintained in place during the entire intervention.

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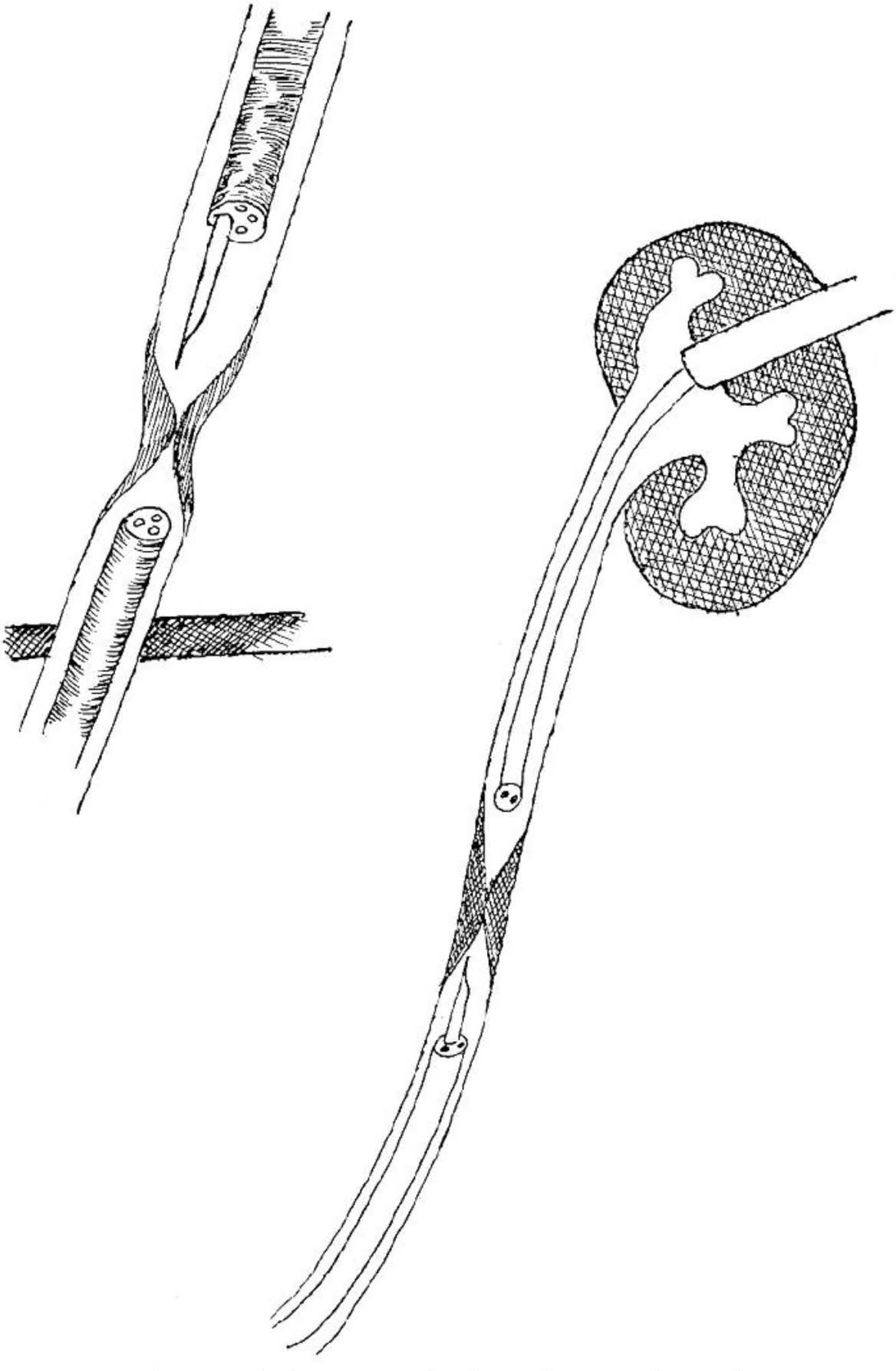

Figure 9.26 **Simultaneous retrograde and antegrade ureteroscopic approach.**

Strictures of uretero-enteral anastomoses can be difficult to treat due to the extensive postoperative periureteral fibrosis, as well as the difficult or even impossible to achieve retrograde access (from the enteral segment). Also, due to the oncological history of the patients, the high risk of local recurrence must be taken into account. In these cases, the success rate is lower compared to other ureteral strictures.

Complete uretero-vesical obstruction, secondary to renal transplantation or ureteral orifice resection, represents a similar problem, and identification of the ureteral orifice may be difficult. In these cases, perforation of the stenosed proximal segment by antegrade approach can be achieved, followed by retrograde incision (Strup and Bagley, 1996).

All authors recommend postoperative internal drainage. As in the case of patients with endopyelotomy, there are controversies regarding the proper dimension of the stent, as well as the period for which it is kept in place (Kerbl et al., 1993; Moon et al., 1995; Hwang et al., 1996). Usually it is preferred to use 6/10 F endoureterotomy stents, positioning the 10 F part at the level of the incised segment. Although there are no comparative studies conducted in significant groups of patients, it is considered that using a common 7 or 8 F JJ stent can be just as efficient.

According to Davis' studies, the muscular tissue of the ureteral wall regenerates in 6 weeks. It is therefore considered that the stent should be kept in place for at least 6 weeks.

Postoperative follow-up consists of imagistic examinations performed to detect any recurrent obstructions: renal ultrasonography, excretory urography, retrograde ureteropyelography, or renal scintigraphy. Renal ultrasonography may show the presence of normal renal parenchyma, as well as the absence of hydronephrosis. The method is advantageous with regard to the cost-efficiency ratio and is easier to tolerate than contrast enhanced imagistic tests. It is usually recommended to repeat it at 3 and 6 months after the procedure, and then once a year if the patient's status remains stable. Any modification detected by ultrasonography requires contrast-enhanced investigations or renal scintigraphy.

9.5.2.5. Results

There are few series of patients that can be analyzed in order to assess the results of incisional endoscopic treatment for ureteral strictures (Table 9.3).

Table 9.3

Endoureterotomy for Benign Ureteral Stenoses

Author	Number of cases	Success rate (%)	Follow-up (months)
Schneider et al. (1991)	12	83	15
Chandhoke et al. (1993)	8	75	4
Eshghi and Lifson (1995)	20	88	–
Cohen et al. (1996)	8	75	29
Wolf et al. (1997)	38	82	28
Singal et al. (1997)	12	67	11
Preminger et al. (1997)	40	71	9
Lopatkin et al. (2000)	7	86	22
Total	145	78	4–29

Most data regarding such incisions are combined with the results of other therapeutic modalities, thus making them difficult to interpret. The comparison of studies that use different techniques can be misleading because the studied groups usually are not homogeneous, with notable differences regarding the type of incision, follow-up period, etiology, and the length and location of strictures.

Endoureterotomy generally associates a success rate of 55–85% in case of benign ureteral strictures (Meretyk et al., 1992; Khaled and Stuart, 2003 Geavlete et al., 2003, 2006).

Endoureterotomy for strictures located in the distal and middle ureter has recorded success rates between 66% and 88%. The mean success rate for the 145 patients (from these combined series) was of 78%, being higher than that obtained by balloon dilation (67%).

In a long-term analysis of the results of endoureterotomy for benign ureteral stenoses by using different incision modalities, Wolf et al. (1997) described a global success rate of 80%. The different modalities that were used did not significantly affect the results. All recurrences occurred within the first year after the intervention, and repeating endoureterotomy was followed by success in 25% of these cases. The authors underlined the fact that all patients in whom the function of the affected kidney represented less than 25% of the global renal function recorded failures of the endoscopic management of benign ureteral strictures. These results support the hypothesis regarding the importance of the urinary flow at the level of the sectioned area with implications in maintaining its permeability. Moreover, injection of steroids at the level of the stenosed area in order to reduce formation of scar tissue did not prove to be efficient in these cases.

Eshghi and Lifson described the results obtained by cold-knife endoureterotomy in 89 patients. The global success rate was 95% for the first procedure and 98% for cases that required repeated procedures. No significant complications secondary to using this technique were recorded (Eshghi and Lifson, 1995).

There are authors who have described success rates for cold-knife endoureterotomy of up to 100%, although the short follow-up period (3–8 months) makes these results questionable (Franco et al., 1994).

Preminger et al. (1997) conducted a multicenter study assessing the Acucise device. The technique was applied in 49 cases, obtaining a success rate of 55% after a mean follow-up period of 8.7 months (between 1.2 months and 17 months).

Thomas (1993) reviewed 36 cases of ureteral strictures treated by endoureterotomy performed with the electrocautery. The intervention was successful in 64% of cases, the results being higher in cases with strictures under 1.5 cm (80%) compared to longer strictures (27%). Also, low success rates were recorded in patients with a history of radiotherapy (33%).

Singal et al. (1997), using Ho:YAG laser endoureterotomy, reported a success rate of 76%.

A lower success rate was obtained for the incision of uretero-enteral strictures, most probably due to their ischemic nature. Thus, Wolf et al. (1997) reported success rates of 73, 51, and 32% at 1, 2, and 3 years after the intervention, respectively. All endoscopic reinterventions failed. Using the Ho:YAG laser, Watterson et al. (2002) obtained favorable results in 56% of cases over a mean follow-up period of 3 years, while Poulakis et al. (2003), using cold-knife endoureterotomy, reported a success rate of 60.5%. The incision of uretero-enteral strictures with the Acucise device recorded relatively modest results, with an efficiency of only 30% after a mean follow-up period of 48 months (Lin et al., 1999).

9.5.2.6. Prognosis

Most studies reveal several predictive factors regarding the long-term results of endoureterotomy.

9.5.2.6.1. Location of the Stricture

Endoureterotomy of distal and proximal ureteral strictures records a higher success rate compared to those located in the middle ureter (Fuchs et al., 2006). Meretyk et al. (1992) describe a success rate of only 25% for strictures located in the middle third of the ureter that benefited from endoscopic incision, compared to 80% positive results in the case of distal and proximal ureteral strictures treated in the same manner.

9.5.2.6.2. Type of Stricture

The stricture's etiology represents an important prognostic factor. A frequent cause of ureteral strictures is represented by fibrosis secondary to open or endoscopic surgical interventions. These lesions, which are relatively nonischemic, have a higher success rate for endoureterotomy compared to poorly vascularized, ischemic strictures (Netto et al., 2000). Ureteral strictures secondary to radiotherapy or to extraluminal metastatic neoplasias, which are based on a mechanism of extrinsic compression, register poor results after endoureterotomy. On the other hand, in patients with lithiasis and associated ureteral stricture, remission of the stricture is observed once the stone is removed and the inflammatory process disappears.

9.5.2.6.3. Length of the Stricture

Most authors state that the treatment of long ureteral strictures (Fig. 9.27) has a very low success rate, regardless of the method of endourological treatment used (endoincision or balloon dilation). Thus, Beckman et al. (2003), in a series of 25 patients with ureteral strictures shorter than 2 cm, describe a success rate of 84% after their balloon dilation. In comparison, in patients with strictures longer than 2 cm, dilation was successful in only 50% of cases. Similar results are also reported regarding endoureterotomy. Based on these data, it can be stated that the indication of endoureterotomy is addressed to ureteral strictures shorter than 2 cm.

structures that require blood transfusions, sepsis, and uretero-enteral fistulas (Hafez et al., 2003; Breyer and Kane, 2006). Thus, Yamada et al. (1995) reported one case (out of 20 patients treated by cold-knife endoureterotomy) with important vascular damage that required immediate laparotomy. The risk of these complications can be reduced by adequate preparation and selection of patients, by assessment of the vascular structures by endoluminal ultrasonography, and by making a correct incision (depending on the affected ureteral segment).

The most frequent late complication after endoureterotomy is represented by restenosis, which may require either repeating the procedure or choosing another therapeutic alternative (placing a metallic stent, ureteral resection with termino-terminal anastomosis, interposition of an intestinal segment – enteroureteroplasty).

9.5.2.8. Controversies

Several controversies exist regarding the endoscopic treatment of ureteral strictures, the most important ones being related to the modality of incision, the choice of the type of stent, and the duration for which it is kept in place. Injection of corticosteroids at the level of the stricture or the use of urothelial stents represents new methods that are under assessment.

9.5.2.8.1. Choosing the Optimal Modality of Incision

There are no significant differences regarding the efficiency of endoureterotomy according to the modality of incision that was chosen: cold knife, electrocautery, Nd:YAG (Fig. 9.28), or Ho:YAG laser. However, Ho:YAG laser incision seems to be preferred by most authors because it offers not only a high success rate, but also an optimal control of the incision and a better hemostasis (Hafez et al., 2003).

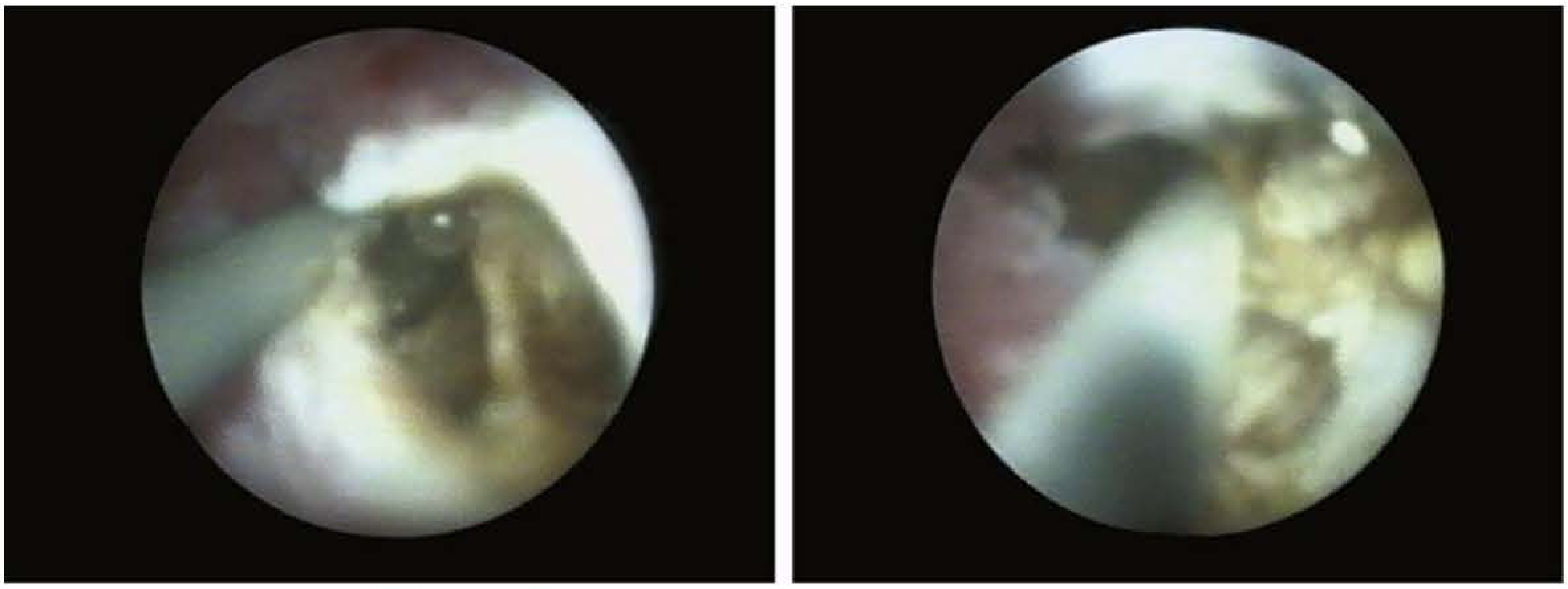

Figure 9.28 **Nd:YAG laser incision of a ureteral stricture.**

9.5.2.8.2. Adjuvant Steroid Therapy

The use of corticosteroids as adjuvant therapy after endoureterotomy is based on the premise that formation of collagen can be blocked, thus reducing the restenosis rate. This method is addressed to certain selected cases: patients with ischemic-type strictures or long strictures, in whom endoureterotomy as a single therapeutic method has a low chance of success (the associated conditions contraindicating an open surgical intervention). The most frequently used agent was triamcinolone in doses of 120 and 200 mg (3–5 mL, 40 mg/mL), injected through a 3 F Greenwald needle into the bed of the incised ureteral stricture. There are not enough data regarding this method's long-term efficacy. The literature describes success rates of up to 50% after 5 years of postoperative follow-up (Breyer and Kane, 2006).

9.5.2.8.3. Caliber of the Stent

There is no consensus regarding the optimal caliber of the ureteral stent used after endoureterotomy. Although ureteral stents with calibers between 5 F and 16 F have been used (Fig. 9.29), no direct correlation could be established between the dimension of the stent used and the efficiency of therapy. Some authors prefer large-caliber stents, while others state that these stents can compromise the vascularization of the affected ureteral segment by mechanical compression (Siegel and Smith, 1993; Hwang et al., 1996). However, recent studies have shown similar results between 6 F and 8 F stents and large-caliber (7–14 F) stents (pyelostent) (Pearle, 2006).

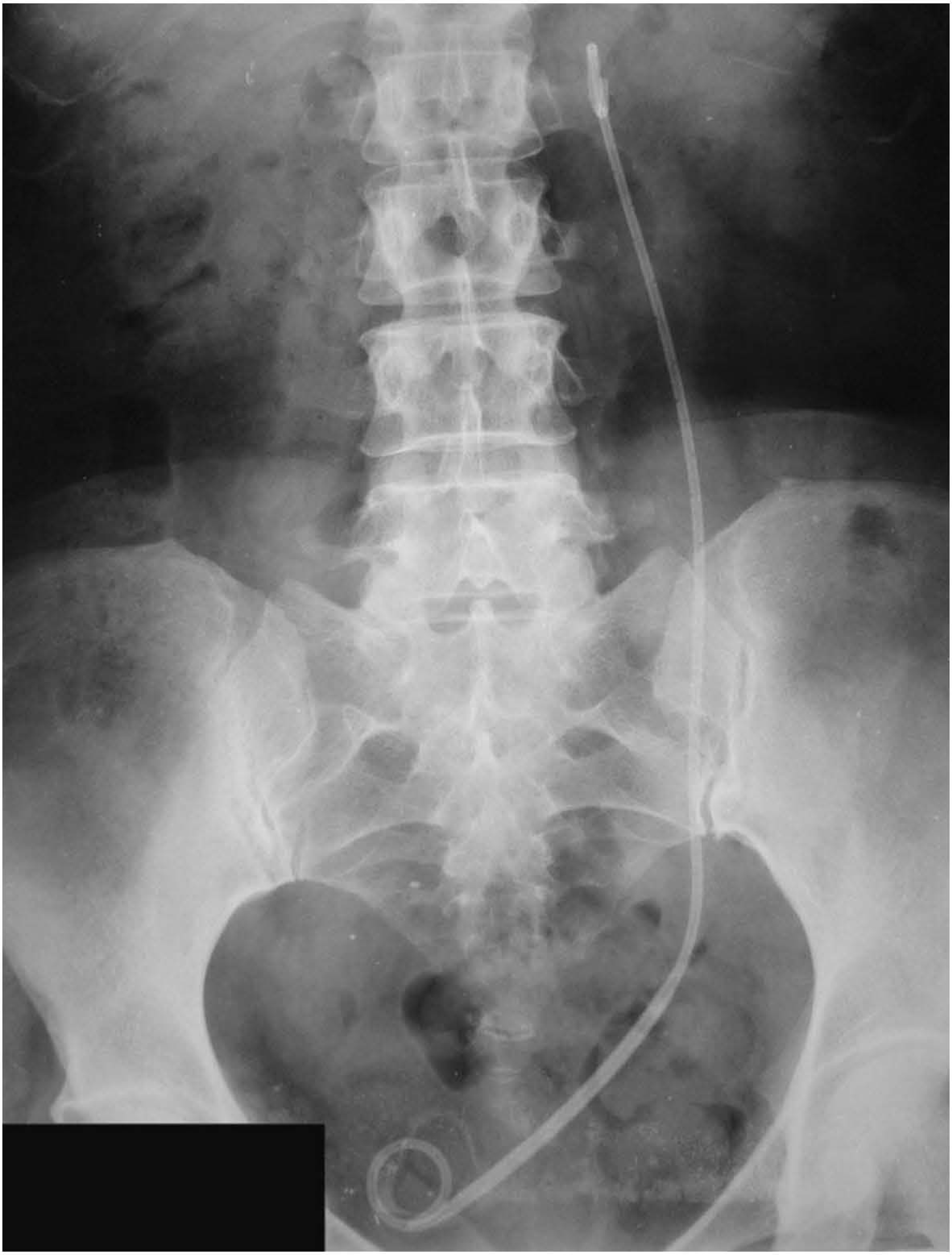
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Figure 9.29 **Pyelostent placed after the incision of a juxtavesical ureteral stricture (simple reno-vesical radiography).**

9.5.2.8.4. Duration of Maintaining the Ureteral Stent

Most authors agree that ureteral stenting after endoureterotomy quickens the healing process, preventing urinary leakage and restenosis. However, maintained for too long, the stents can generate inflammation, muscle fiber hyperplasia, or scars, processes that may compromise healing. There is currently no consensus regarding the optimal period for maintaining a ureteral stent after endoureterotomy. Kerbl et al. (1993) report similar results regarding the success rate of ureteral strictures regardless whether the period for maintaining the postoperative stent was 1, 3, or 6 weeks.

9.5.3. Metallic Stents

The successful use of metallic stents in the treatment of diseases of the vascular system and of the biliary tract led to their introduction as a therapeutic alternative in the management of urinary tract diseases.

The first applications of metallic stents in the treatment of ureteral stenoses were described by Gort in 1990. Pauer and Lugmayr were the first authors to use metallic stents in the management of patients with malignant ureteral stenoses (Pauer et al., 1992). The continuous improvement of the quality and design of metallic stents gradually led to their large-scale use. Regarding the indications for using metallic ureteral stents, they have not yet been completely systematized, most authors recommending their placement especially in malignant ureteral stenoses. It is generally accepted that patients with benign stenoses longer than 2 cm, with multiple recurrences, with associated conditions that contraindicate an open surgical intervention, may benefit from placing a metallic stent (Fig. 9.30).

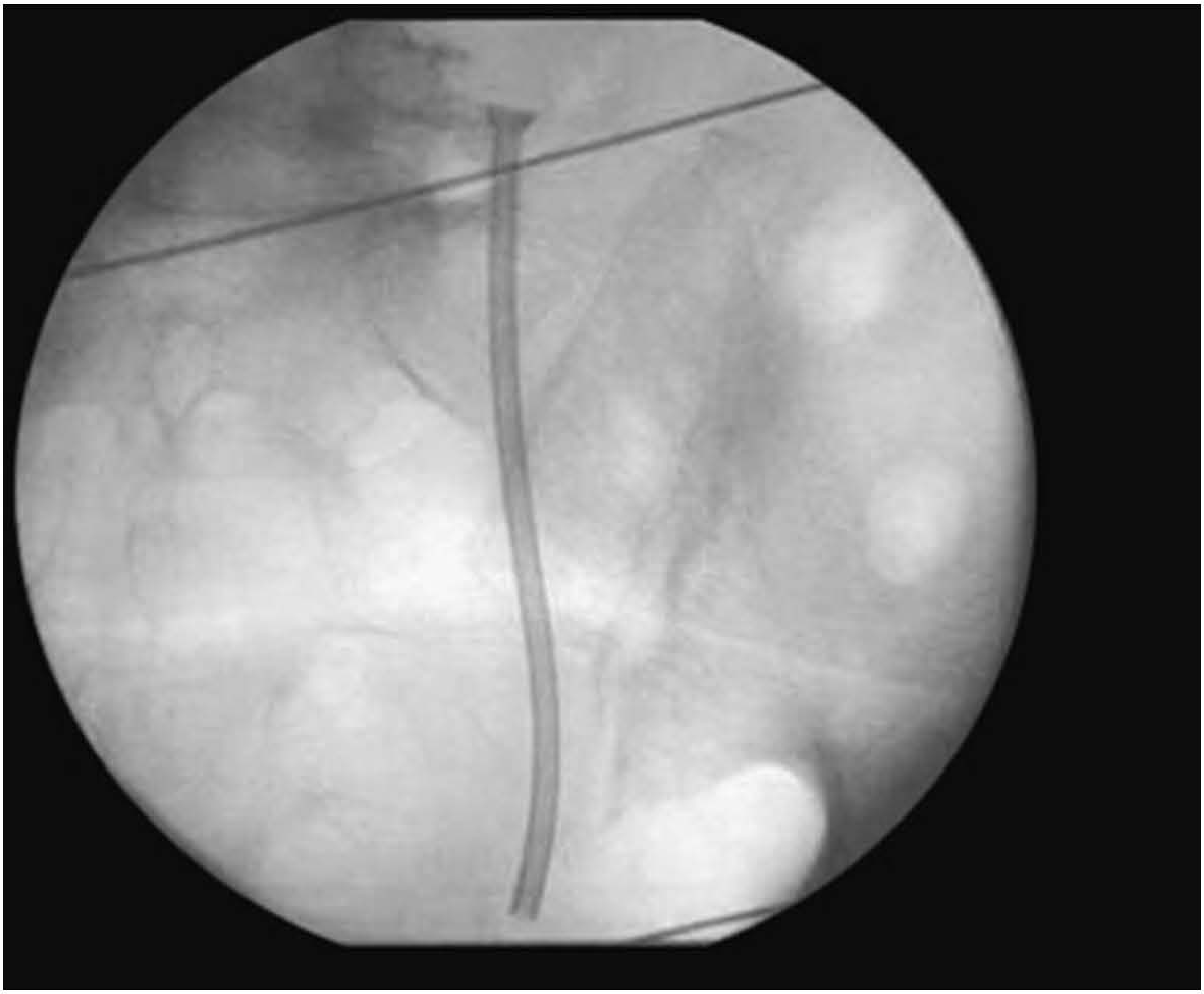

Figure 9.30 **Metallic stent placed for a pelvic ureteral stricture.**

Thus, Herrero described good results by inserting metallic stents in patients with ureteral stenoses after kidney transplantation (Herrero, 1996). Liatsikos et al. (2005) describe the use of thermoexpandable metallic stents in the management of uretero-ileal stenoses. Kulkarni and Bellamy (2001) published the results obtained in a group of 10 patients with ureteral obstruction secondary to a benign recurrent condition (endometriosis, fibrosis after radiotherapy, etc.), followed over a period of 10.6 months; remission of obstruction after inserting a metallic stent was described in all cases. Arya et al. (2001) followed for 18 months a group of 13 patients with benign ureteral strictures in whom metallic stents were placed, describing only three cases that presented stent encrustation (which required its removal at 4, 11, and 33 - months, respectively). Similar results were also described by Daskalopoulos et al. (2001).

9.6. Particular situations

9.6.1. Uretero-Enteral Strictures

Uretero-enteral strictures occurring in patients with radical cystectomy and urinary derivation represent a difficult to treat condition. In the past, the only alternative was represented by open surgical reintervention with excision and reimplantation of the affected ureter. Technological advances presently offer a variety of minimally invasive options. Although none of these have equaled the success rates obtained by open surgery, they offer many benefits: low morbidity, short hospitalization period, minimal complications, and rapid social reintegration.

The global incidence of anastomotic strictures after cystectomy and urinary derivation varies between 3% and 9% (Novotny et al., 2004), the mechanism of appearance being ischemic.

9.6.1.1. Indications

Not all patients with urinary derivations and hydronephrosis require surgical intervention. Most of these patients present a degree of hydronephrosis that is not secondary to any obstruction of the uretero-enteral anastomosis.

Most patients who develop uretero-enteral strictures that have surgical indication present an alteration of renal function together with a symptomatic picture that may include pain, hematuria, or recurrent infections. In these situations, the imagistic assessment of the upper urinary tract is required.

9.6.1.2. Management

Open surgical intervention with excision of the stenosed area and ureteral reimplantation has represented the gold standard in the treatment of uretero-enteral strictures. However, this is an operation with significant morbidity, including a large variety of possible complications: infection of the surgical wound, vascular lesions, gastrointestinal complications, etc. (Laven et al., 2003). The success rates for this procedure range from 80% to 91% (DiMarco et al., 2001; Laven et al., 2003).

9.6.1.3. Balloon Dilation

The evolution of percutaneous surgery in the treatment of renal lithiasis has represented an important factor for the development of the antegrade treatment of uretero-enteral strictures. In 1979, Smith and coworkers were the first to describe percutaneous balloon dilation of a uretero-ileal stricture. Several cases of percutaneous balloon dilation for uretero-enteral strictures were published shortly after, but many patients required multiple procedures, and postoperative follow-up showed low success rates (Martin and Frankuchen, 1984; Banner and Pollack, 1984).

The technique, similar to that described for other types of benign ureteral strictures, implies inflating a balloon under high pressure, under radiological control, followed by ureteral stenting (Figs 9.31 and 9.32).

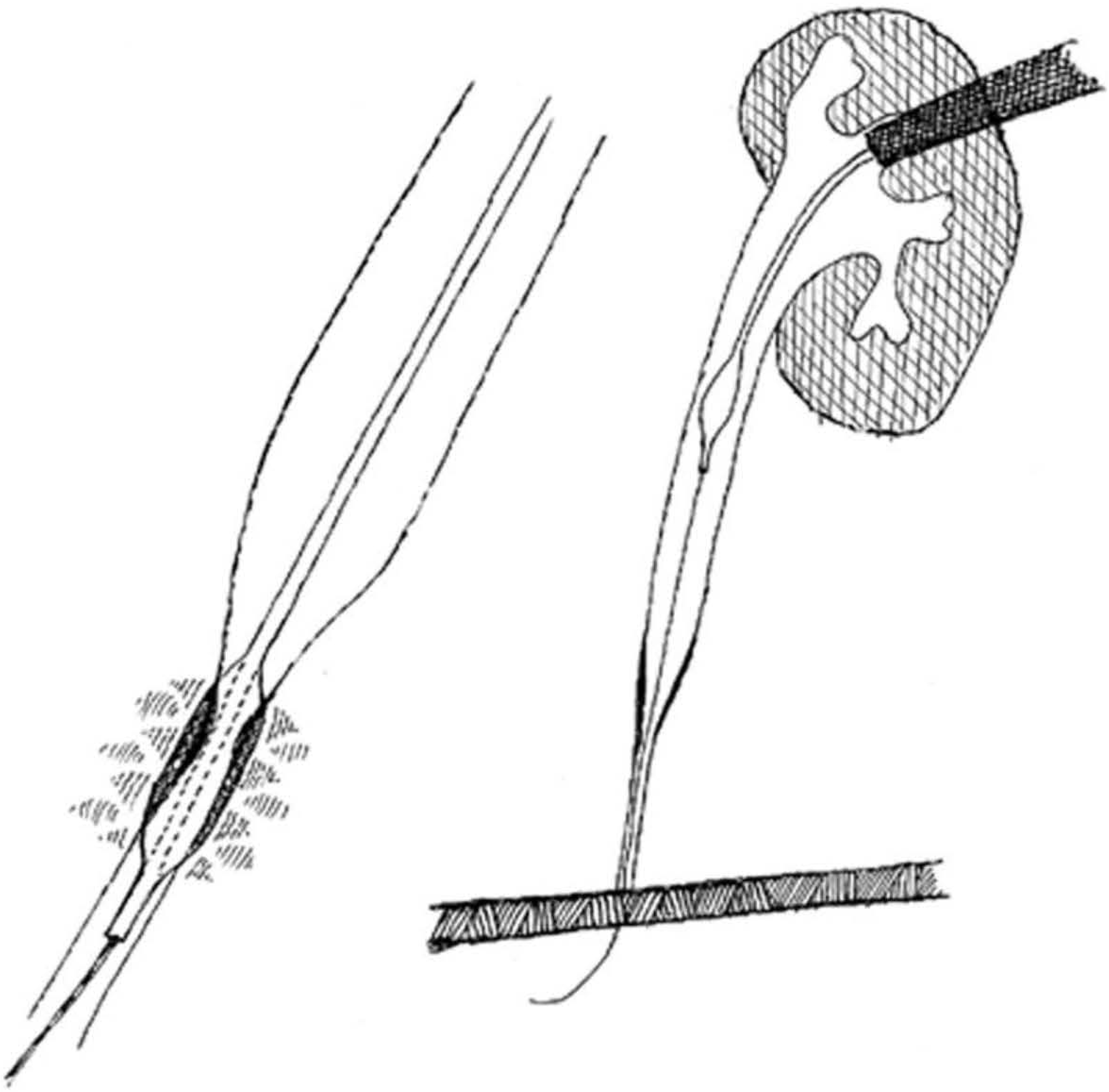

Figure 9.31 The technique of balloon dilation for uretero-enteral strictures.

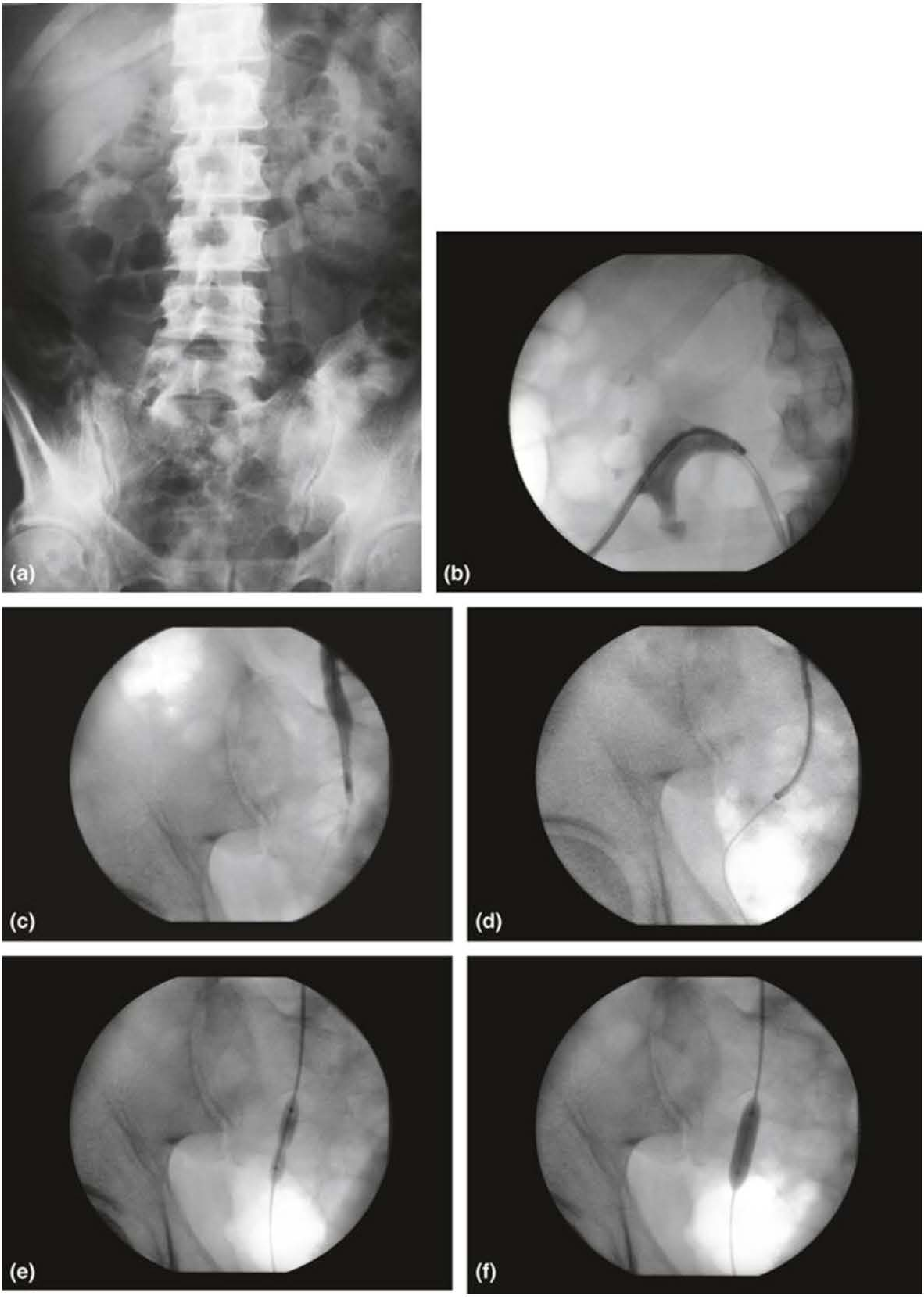

Figure 9.32 **Balloon dilation for a uretero-enteral stricture: control intravenous urography which shows left ureterohydronephrosis (a), antegrade approach using the flexible ureteroscope (b), observing the stenosis area (c) and placement of a metallic guidewire (d), introduction of a balloon catheter and dilation of the stricture under fluoroscopic control (e, f).**

The success rates vary between 13% and 18% (Table 9.4). The type of balloon used (between 4 mm and 10 mm) did not significantly influence the treatment's efficiency. Also, the inflation pressure (5–17 atm), time (30 s to 15 min), and number of cycles (1–3) did not significantly change the results obtained. The most recent and largest series, including 52 procedures, presented success rates of 15, 15, and 5% at 1, 2, and 3 years, respectively (DiMarco et al., 2001).

Table 9.4

The Results Obtained After Balloon Dilation of Uretero-Enteral Strictures

Author	Number of procedures	Follow-up period (months)	Success rate
Shapiro et al. (1988)	37	12	6 (16%)
O'Brien et al. (1988)	8	12	1 (13%)
DiMarco et al. (2001)	52	24	8 (15%)
Total	102	17.5	18 (18%)

The physiopathological explanation for these results may be represented by the fact that the area of fibrosis was never completely interrupted in order to allow for a sufficient ureteral regeneration.

9.6.1.3.1. Endoureterotomy

As for the other benign strictures, the endoscopic incision of the stenosis area may be achieved with the Acucise device, the cold knife, the electrocautery, or laser. The incisions must include 1 cm of the underlying and overlying ureter and must penetrate the entire thickness up to the periureteral fat or until leakage of the contrast media is visible radiologically.

The incision must be directed anteriorly or medially in order to avoid damage to the iliac vessels or to the neighboring vascular structures. The approach and the therapeutic modality can be individualized according to the type of urinary derivation and the stricture's characteristics. However, antegrade approach is easier using the flexible ureteroscope inserted through a nephrostomy pathway (Geavlete et al., 2006) (Fig. 9.33). This can generally be inserted on a guidewire up to the level of the stricture area (Fig. 9.34). Many authors even prefer to use a flexible cystoscope or nephroscope inserted antegradely.

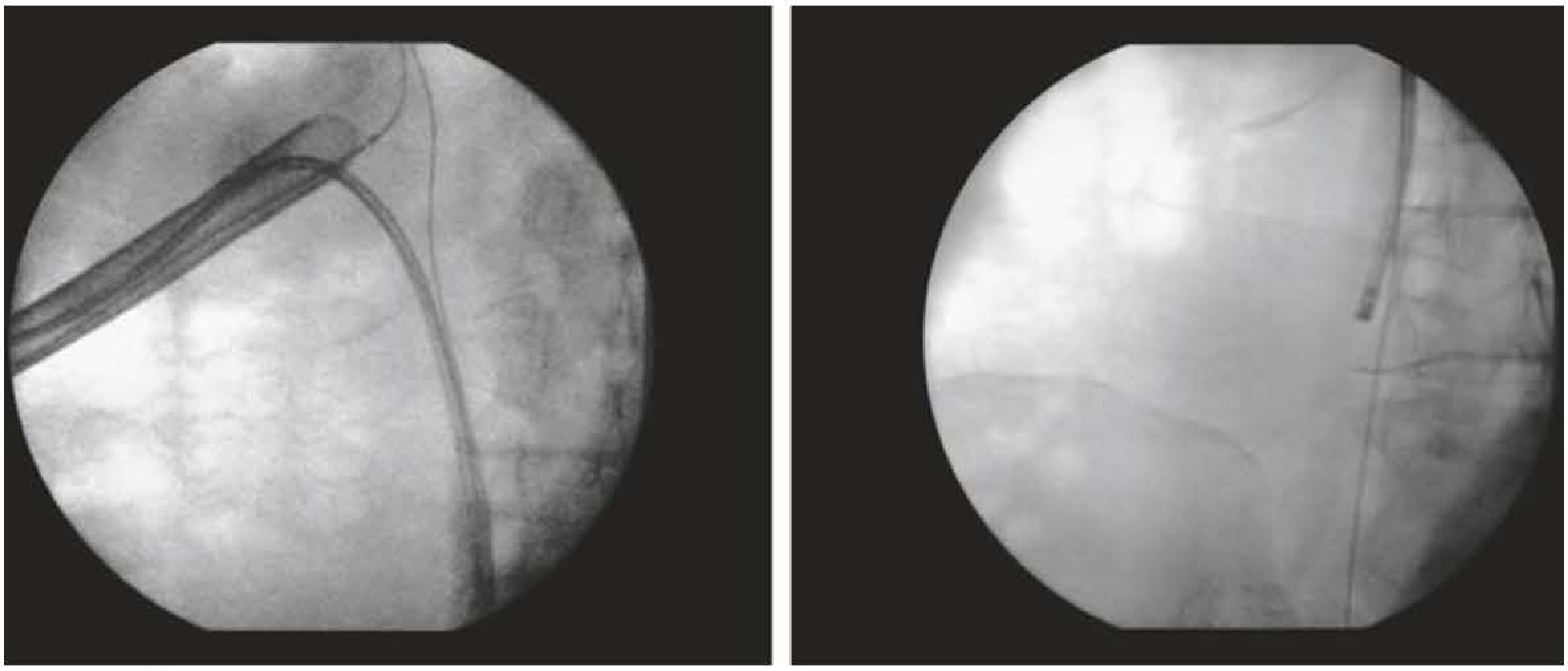

Figure 9.33 **Antegrade approach for a uretero-enteral stricture using the flexible ureteroscope.**

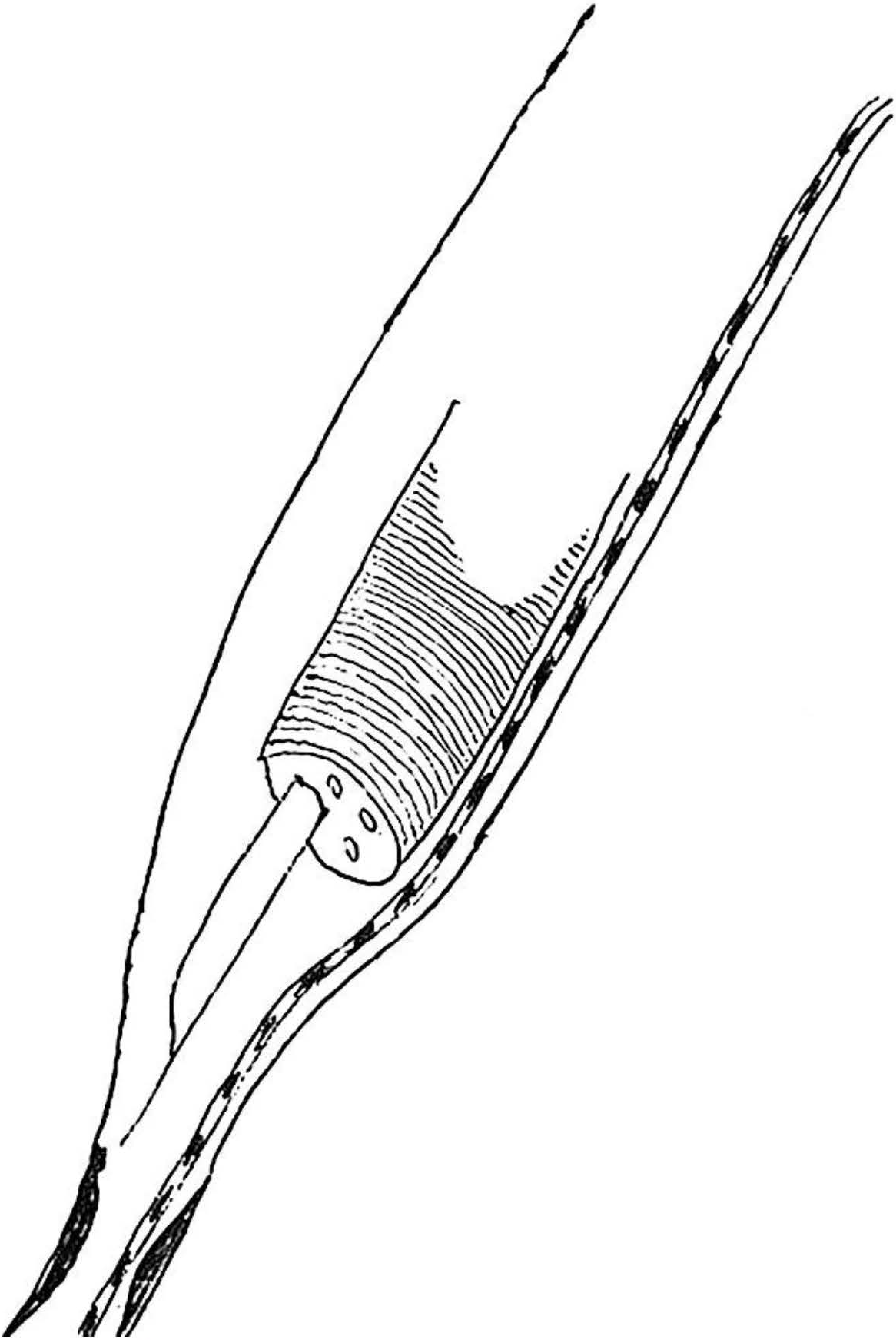

Figure 9.34 **The technique of antegrade incision for a uretero-enteral stricture.**

A series of recent studies assessing the efficiency of endoureterotomy performed for uretero-enteral strictures have been published in the literature (Table 9.5). The major obstacle in assessing the results is that the series frequently include patients with short follow-up periods.

Table 9.5

The Results Obtained After Endoureterotomy for Uretero-Enteral Strictures

Author	Number of procedures	Follow-up period	Stent (F)	Duration of stenting (weeks)	Success rate
Cold knife					
Poulakis et al. (2003)	43	39	8–12	6–12	26 (60.5%)
Acucise					
Babayan (1995)	9	3	–	–	3 (33%)
Kabalin (1997)	4	22	10	6	4 (100%)
McDougall and Nakada (1997)	1	12	10	3	1 (100%)
Lin et al. (1999)	10	24	10	6	3 (30%)
Wolf et al. (1997)	9	12	16	4	7 (78%)
Preminger et al. (1997)	6	9	–	6	3 (50%)
Total	39	15			24 (62%)
Ho:YAG laser					
Watterson et al. (2002)	24	22	12	6	17 (71%)
Laven et al. (2003)	16	35	6	4–6	8 (50%)
Total	40	29			25 (63%)

Endoureterotomy can be performed in a retrograde manner, using a semirigid uretero-resectoscope (Delvecchio and Preminger, 2000). One of the technical difficulties of endoureterotomy in these cases is represented by identification of the stenosis area. The use of a guidewire over which the cold knife can slide allows the performance of the procedure both in a retrograde and in an antegrade manner, under direct visual control. However, the limited flexibility and the insufficient intraoperative hemostasis are disadvantages that limit the use of this modality of incision. Nevertheless, the results of cold-knife incisions have shown to be better than those obtained after simple balloon dilation, with long-term success rates of up to 60% (Poulakis et al., 2003).

Electroincision can be performed either using a 2–3 F electrode (inserted through the rigid or flexible ureteroscope) or the Acucise device. Unfortunately, the results obtained using this modality of endoincision are poorer (mean success rate of 62%) compared to those obtained in pyeloureteral junction stenosis (75%).

Laser incision of uretero-enteral strictures has gained ground due to the flexibility of the 200 µm laser fibers and to the adequate intraoperative hemostasis. Although several types of lasers can be used (Nd:YAG, KTP), the most frequently used is the Ho:YAG laser (at a mean power of 10 W) (Watterson et al., 2002). The results are promising, with success rates of up to 71%.

9.6.1.3.2. Metallic Stents

Similar to other types of ureteral strictures, uretero-enteral strictures may also benefit from placement of metallic stents.

The most frequently used device described in the literature for such cases is represented by a self-expandable stent made of stainless steel, with diameters between 8 mm and 10 mm and with lengths ranging from 4.2 cm to 6.8 cm, called the Wallstent (Boston Scientific, Natick, MA).

These stents are generally placed after endoureterotomy or balloon dilation. The success rates are encouraging, but the series of patients are limited and the follow-up periods are short (Table 9.6).

Table 9.6

The Results Obtained After Using Metallic Stents for Uretero-Enteral Strictures

Author	Number of procedures	Follow-up period (months)	Success rate
Gort et al. (1990)	1	6	1 (100%)
Sanders et al. (1993)	2	7	2 (100%)
Reinberg et al. (1994)	2	13	2 (100%)
Pollack et al. (1995)	6	11	1 (17%)
Barbalias et al. (1998)	6	12	6 (100%)
Palascak et al. (2001)	10	22	10 (100%)
Daskalopoulos et al. (2001)	3	9	3 (100%)
Total	30	–	25 (83%)

The efficiency of this therapeutic alternative varies between 17% and 100%, with an average of 83%.

The long-term complications of metallic stents include calcification, spontaneous expulsion, and urothelial hyperplasia, which may determine obliteration of the ureteral lumen and obstruction. Urinary derivations present a higher incidence of encrustations and of calculi formation, most probably due to urinary stasis. Limiting the part of the stent that protrudes into the urinary reservoir is very important for reducing this risk. Adding a biocompatible polymer (Corethane) may reduce the incidence of urothelial proliferation around the metallic stents. Other types of stents used are the Memokath stent (Engineers & Doctors A/S, Copenhagen, Denmark) and the Strecker stent (Boston Scientific, Natick, MA).

9.6.1.4. Prognostic Factors

Most authors generally agree with the fact that the success rate in the case of uretero-enteral strictures is much lower compared to benign ureteral strictures of other etiologies. Thus, in general, the success rate at 3 years after endoureterotomy is around the value of 80% for benign ureteral strictures, compared to 32% for the uretero-enteral ones (Wolf et al., 1997).

As in the case of benign ureteral strictures, the existence of a functional ipsilateral kidney is considered to be an important prognostic factor. The decrease of renal function below 25% entails, in most cases, the failure of endoureterotomy.

The explanation lies in the fact that the epidermal growth factor, which has a catalytic role for the mitogenic activity (vital for stimulating ureteral regeneration), is reduced in cases with affected renal function.

The type of urinary derivation does not represent a significant prognostic factor regarding the success of endoureterotomy. However, uretero-enteral strictures are twice as frequent on the left side compared to the right, with a significantly lower success rate after endourological treatment.

Other predictive factors for the success of endoureterotomy can also be identified by analyzing the data published in the literature: the approach of strictures in less than 24 months from the creation of the urinary derivation, use of a 12 F or larger stent, a stenting period of over 4 weeks. Repeating endoureterotomy after a failed intervention may represent a reasonable alternative (Wolf et al., 1997).

In conclusion, uretero-enteral strictures remain the most difficult to treat of all ureteral strictures. Endoureterotomy should be taken into consideration as an elective initial treatment for correctly selected patients. Studies have not clearly shown any significant advantage for any of the cutting modalities. The use of metallic stents seems promising, but is still affected by complications such as tissular proliferation and recurrent obstruction. Future research regarding metallic stents covered with polymers may continue to improve these results.

9.6.2. Strictures After Uretero-Vesical Reimplantation

Stenosis of the transplanted ureter's anastomosis has been described with an incidence of 4–11%, being closely linked to the type of reimplantation used (Thiounn et al., 1991; Faenza et al., 1999). Ureteral obstruction may occur both through an intrinsic mechanism, as well as through an extrinsic mechanism (perirenal collection, urinoma, hematoma, etc.). Ureteral strictures usually occur in the immediate postoperative period, but their formation may sometimes last up to 5 years.

Classically, open surgery was used for the management of stenoses of the transplanted ureter. However, these interventions are associated with an increased morbidity and a prolonged convalescence, and at the same time can be difficult from a technical point of view.

The endourological treatment of these stenoses was generally performed on small series of patients.

The most frequently used method of treatment for this type of stricture consists of pressure balloon dilation followed by stenting with a 7–14 F stent for a period of 4–14 weeks (Fig. 9.35). The success rate at 2 years is 40–70%.

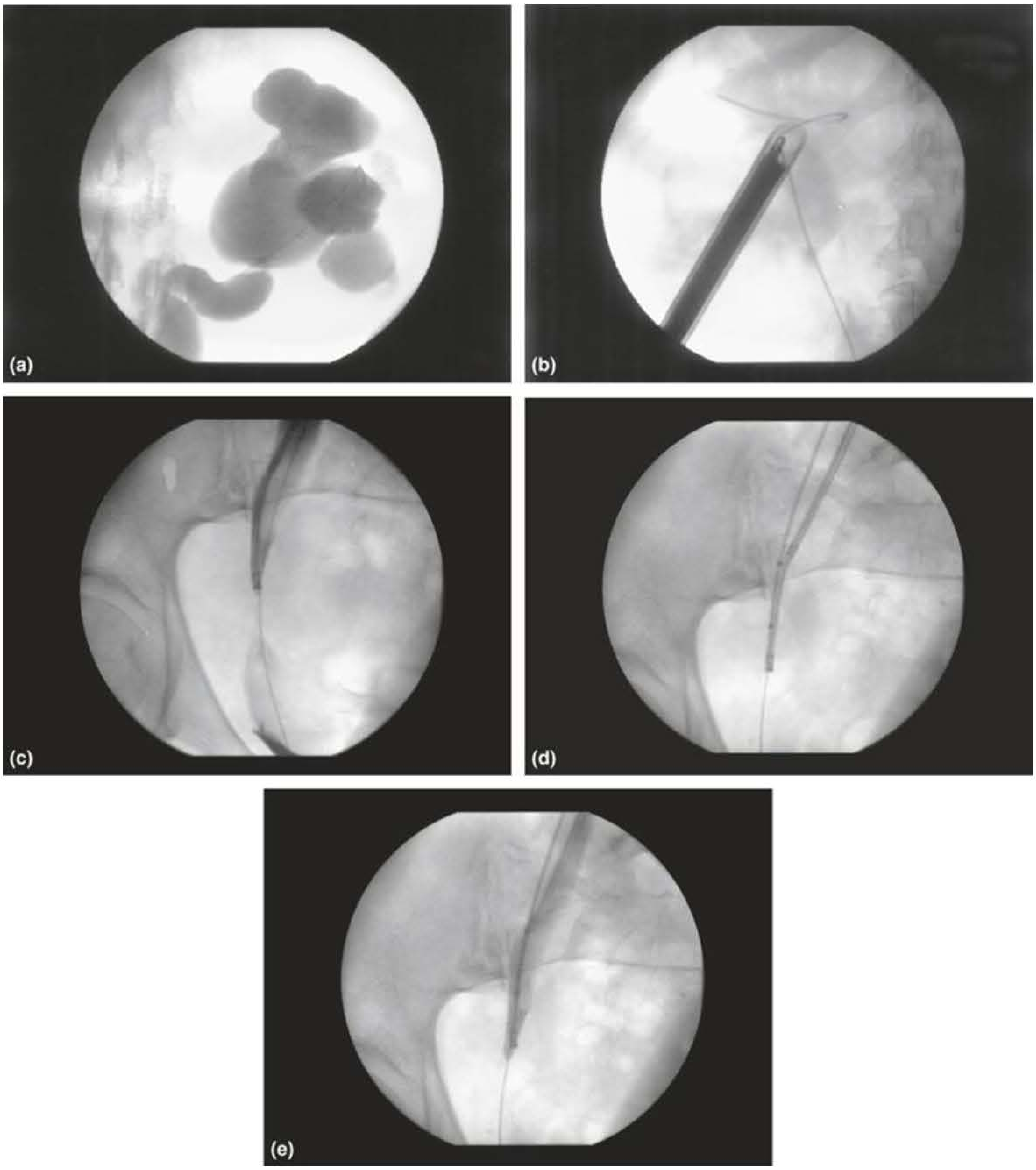

Figure 9.35 **Balloon dilation for a stricture after uretero-vesical reimplantation: left ureterohydronephrosis – preoperative fluoroscopic aspect (a), antegrade approach (b) using the flexible ureteroscope (c), placement of the balloon catheter under fluoroscopic and ureteroscopic control (d) and dilation of the stricture area (e).**

Distal ureteral strictures, as well as those at the level of the uretero-vesical anastomosis, are more frequent compared with those of the proximal ureter and respond better to endourological treatment (75% vs. 16%) (Pardalidis et al., 1994).

Endoureterotomy is used with success rates of up to 82%. A similar success rate was also reported in case of using the Acucise device (Youssef et al., 1994).

9.6.3. Malignant Ureteral Strictures

Ureteral strictures secondary to recurrent urothelial tumors or to extrinsic mechanical compression represent a separate category of strictures that are frequently difficult to treat, requiring multiple therapeutic procedures.

The etiology of these strictures is marked by retroperitoneal lesions secondary to malignant conditions (Table 9.7).

Table 9.7

The Main Conditions Involved in the Etiology of Malignant Ureteral Strictures

Cervix carcinoma
Prostatic adenocarcinoma
Colorectal carcinoma
Bladder cancer
Ovarian cancer
Lymphoma
Endometrial carcinoma
Retroperitoneal sarcoma
Gastric carcinoma
Retroperitoneal metastases

The classic surgical treatment for this condition (surgical nephrostomy, cutaneous ureterostomy, ileal, or colic urinary derivation) is marked by high costs, important morbidity, and mortality (Lang and Fritzsche, 1994). In order to avoid the use of invasive procedures in patients with a limited life expectancy, most authors prefer using minimally invasive therapeutic options, which are also advantageous with regard to the cost-efficiency ratio (Lugmayr and Pauer, 1992; Pauer, 1992; Van Sonnenberg et al., 1994). The main purpose of treatment in these cases is represented by maintaining renal function within relatively normal limits (Richter et al., 2000).

The classic endourological treatment for extrinsic neoplasic ureteral stenoses may include the following minimally invasive alternatives: internal drainage with JJ catheters (placed retrogradely or antegradely), percutaneous nephrostomy, balloon dilation, or combinations of these techniques.

In these cases, endoscopic incision has unsatisfactory results, most authors agreeing that it does not represent a viable therapeutic option (Richter et al., 2000).

The attempts to maintain an adequate diameter of the ureteral lumen using balloon dilation have been disappointing. Thus, the success rate at 2 years was approximately 7% (Lang and Fritzsche, 1994; Lang, 1995). Shapiro et al. (1988) and Richter et al. (2000) have reported similar results. The relatively low number of patients treated this way does not allow significant statistical analysis.

The long-term use of JJ catheters replaced every 3 months may represent a solution, especially for patients with a reserved prognosis (Lu et al., 1994; Debaere et al., 1994). Although there are relatively few studies published in the literature regarding the efficiency of internal drainage with JJ catheters, the failure rates are high, especially in the case of using polyurethane or polyethylene stents (Docimo and DeWolf, 1989). Thus, after 2 months, internal drainage proved to be insufficient in approximately 45% of patients (Docimo and DeWolf, 1989). In some cases, the JJ catheters may become nonfunctional immediately after being placed.

The recent technical advances have allowed for the introduction into practice of special stents for malignant ureteral strictures: "tumoral stents." In the central part, these are made of a tough plastic, with minimal deformation, while the ends are made of an elastic material. The results obtained demonstrate the superiority of these stents (Schlick et al., 1998).

The use of two JJ catheters positioned ipsilaterally was first described by Liu and Hrebinko (1998), and studies conducted by other authors were published subsequently (Hamm and Rathert, 1999; Geavlete et al., 2007b). The space created between the two stents allows for improving urinary drainage, with better results compared to the use of a single JJ catheter. The technique consists of placing two metallic guidewires at the level of the pyelocaliceal system, followed by the simultaneous introduction of two JJ catheters under fluoroscopic control (Fig. 9.36).

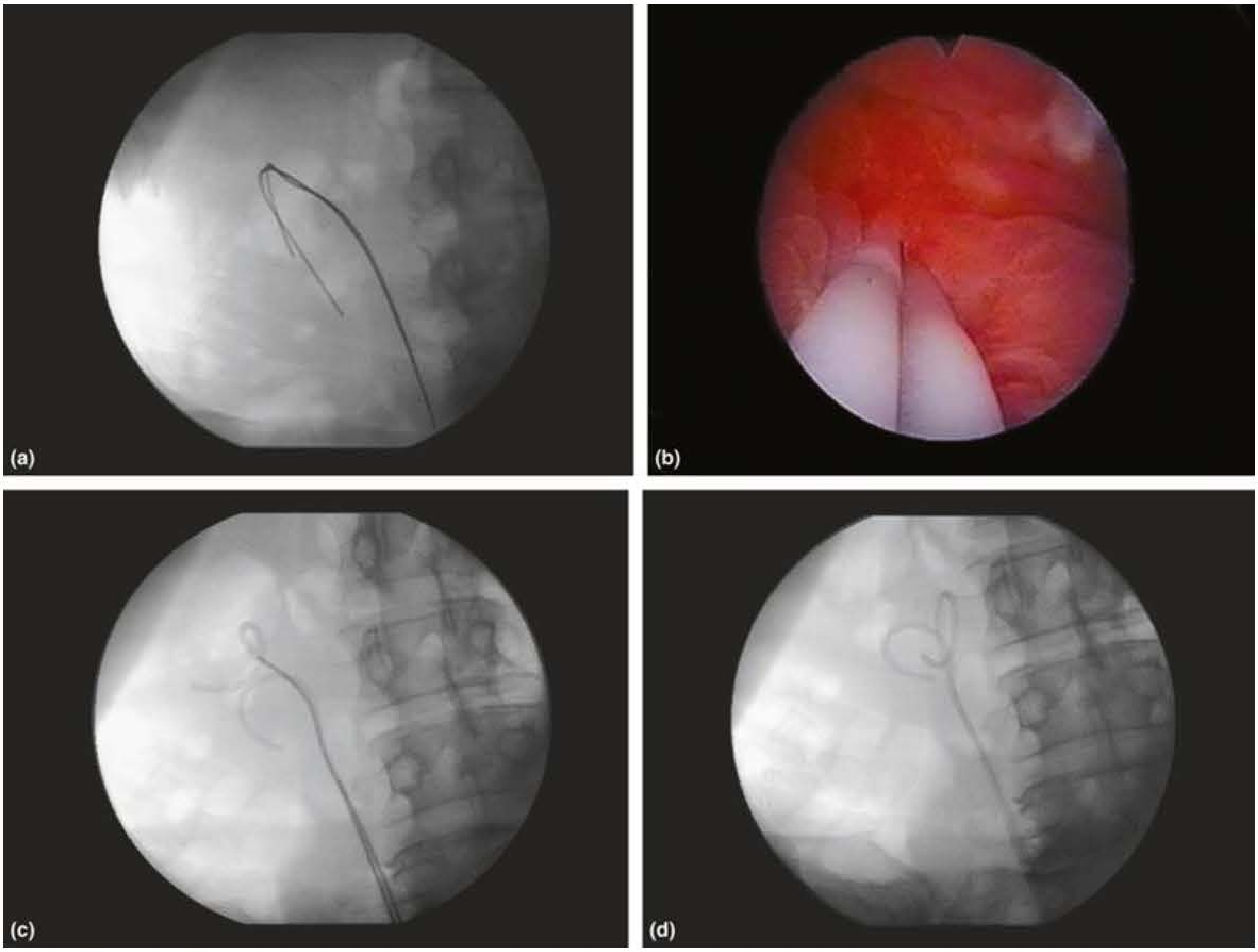

Figure 9.36 **Ipsilateral positioning of two JJ catheters in a patient with malignant ureteral stricture.** Placement of two metallic guidewires (a), simultaneous ascent of the two JJ catheters (b, c), and final fluoroscopic aspect (d).

The results obtained have been encouraging. Thus, in 48% of patients drained with a single JJ catheter, the resistivity index (measured by Doppler sonography) indicated the absence of obstruction after positioning two JJ catheters (Fig. 9.37). A significant reduction in the degree of hydronephrosis was described in approximately 78% of cases, the results being stable after 6 months in 66% of cases (Geavlete et al., 2007b).

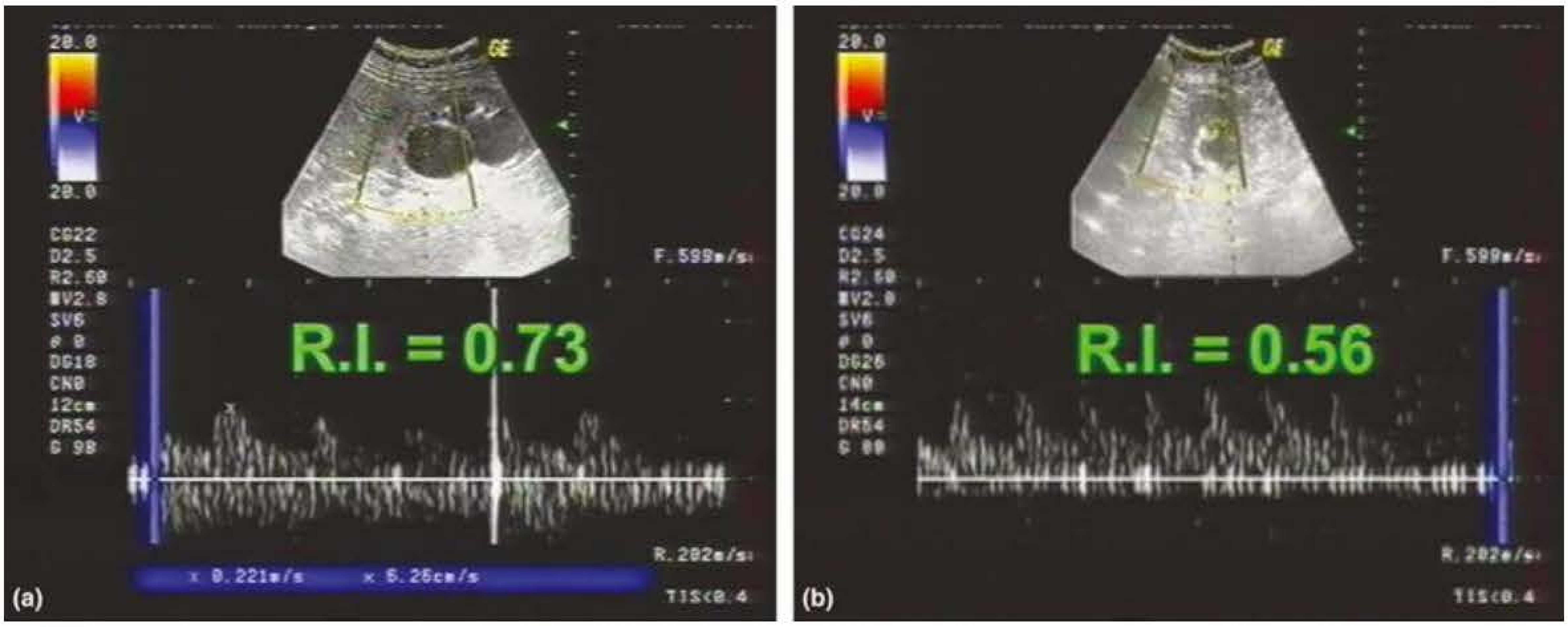

Figure 9.37 **Doppler sonography in a patient with ureteral stricture for which two JJ catheters were placed.** (a) Preoperative obstructive RI and (b) postoperative nonobstructive RI.

However, the ipsilateral positioning of two JJ catheters is a difficult maneuver, even impossible to perform in many cases.

Recent research has aimed at introducing the "ideal stent" into practice: easy to maneuver, stable after insertion, radiopaque, resistant to encrustation and infection, long-term use, and with a low cost (Lugmayr and Pauer, 1996; Kulkarni and Bellamy, 1999). Thus, metallic ureteral stents were introduced into practice in 1990. Four types of metallic ureteral stents are described in the literature: self-expandable, expandable with the help of a balloon, stents covered with polyester, and thermoexpandable stents (Kulkarni, 2003; Liatsikos et al., 2005) (Table 9.8).

Table 9.8

The Main Types of Metallic Stents Described in the Literature

Stent	Manufacturer
Wallstent	Boston Scientific, Natick, MA
Accuflex	Meditech/Boston Scientific, Natick, MA
Strecker	Meditech/Boston Scientific, Natick, MA
Protege	EV3, Plymouth, MN
Luminexx	Bard, Covington, GA
Passager	Boston Scientific, Natick, MA
Memokath 051	Engineers & Doctors, Hornbaek, Denmark

The Memokath 051 stent (Engineers & Doctors, Hornbaek, Denmark), used in practice since 1995, represents the only thermoexpandable metallic stent made of nickel-titanium (nitinol) in which the design of the spirals prevents "endothelial invasion." The thermal memory allows it to be easily positioned (at 50–55°C) and extracted (at 10°C). Moreover, the metallic spirals adapt to the ureteral curvature, determining a low risk of secondary ischemia and of ureteral wall affection. Also, it is a known fact that titanium is an element resistant to corrosion, so the stent can be maintained in the urinary tract for long periods of time.

The diameter of the ureteral stents that are used vary from 10.5 F (before expansion) to 20 F (at the proximal end after expansion). The standard lengths are of 30, 60, 100, 150, and 200 mm. It is recommended to have all the available dimensions at the moment of the intervention, the choice of the stent's exact dimension being made intraoperatively.

The insertion technique was described by many authors (Kulkarni and Bellamy, 2001; Liatsikos et al., 2005; Geavlete et al., 2007a) (Fig. 9.38).

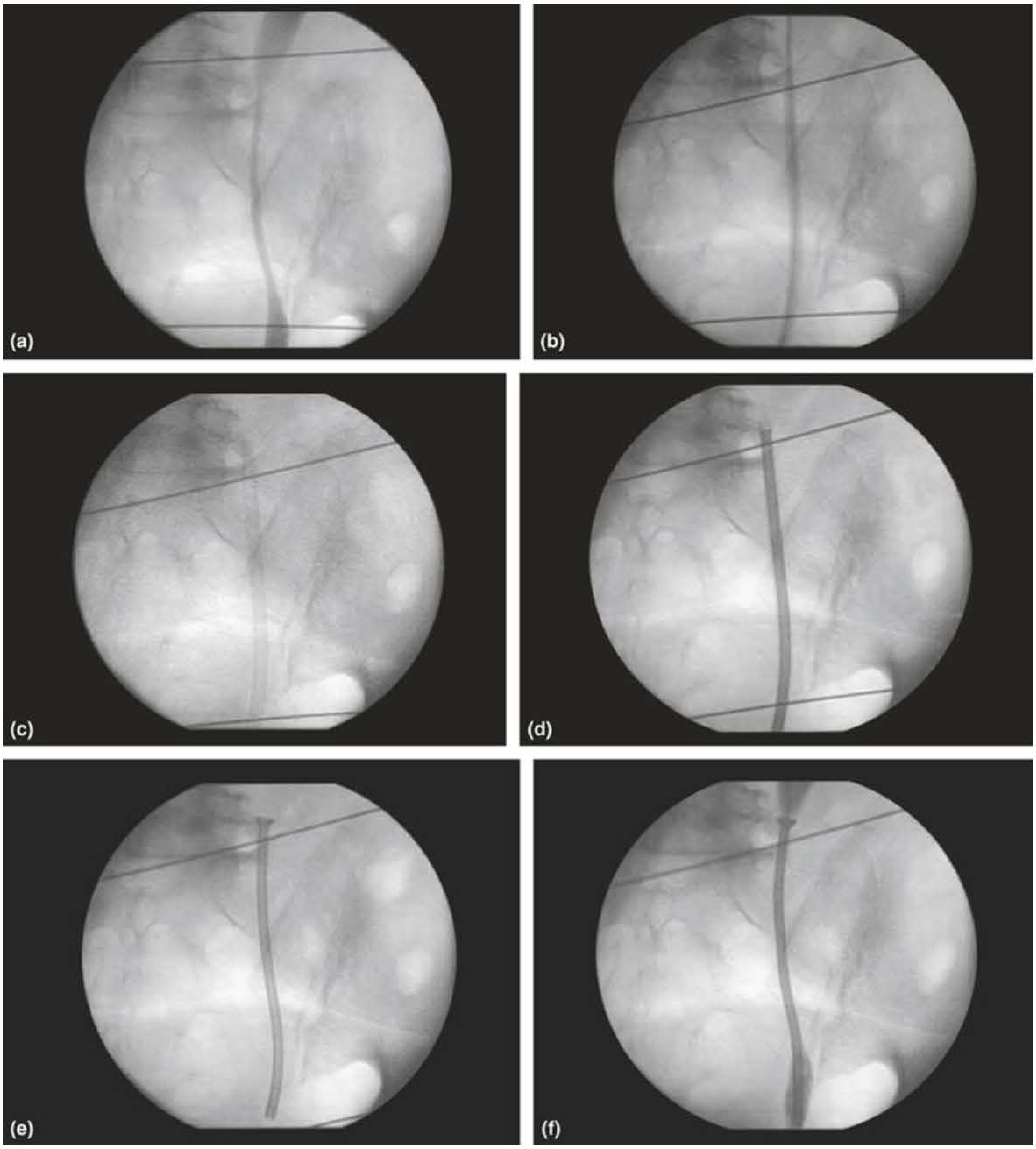

Figure 9.38 **Positioning of a metallic stent (main operative steps).**
Marking the ends of the stricture with radiopaque markers (a), dilation of the ureteral stricture with the help of the dilator included in the insertion kit (b), positioning of the dilator's sheath between the two extremities of the stricture area (c), positioning of the ureteral stent (d), expansion of the distal end of the stent (e), and fluoroscopic and ureteroscopic control of the correct positioning of the stent (f).

The first operative step consists of performing a retrograde ureteropyelography in order to detect the position and length of the ureteral stricture. The proximal and distal ends of the stricture are marked by placing radiopaque markers (percutaneous renal puncture needles) on the operating field under fluoroscopic control, both for measuring the exact length and for visualizing its position without contrast media. After marking the stricture, a 0.038 in. reinforced metallic guidewire is inserted, on which the dilation of the stricture with the 14 F dilator included in the insertion kit is achieved. The metallic guidewire together with the dilator's mandril are extracted, leaving in place its sheath positioned between the two extremities of the stricture area. The stent is inserted through the dilator's sheath and is correctly placed, followed by the expansion of the stent's distal end by injecting 20 mL of sterile water or saline solution heated to 60°C. The complete and correct expansion of the stent is checked under fluoroscopic control, after which the insertion system is extracted. The fluoroscopic and ureteroscopic control of the correct positioning of the stent is done at the end of the procedure.

If an incorrect placement of the stent is remarked, it can be repositioned. In order to achieve this, 20–50 mL of sterile water at 5°C are injected, bringing the distal end of the stent back to its initial dimensions, after which with the help of the ureteroscope or of a balloon catheter inflated at the level of the stent's lumen, it is ascended or descended. Twenty milliliters of sterile water at 60°C are again injected at the end of the procedure in order to achieve the re-expansion of the proximal end of the stent and to fix it in the desired position.

If, for different reasons, it is necessary to extract the stent, this can be done easily by injecting 50 mL of sterile water at 5°C, followed by catching the distal end with a grasper clamp. The stent's spirals will disorganize, resulting in a metallic wire.

This unique property of the Memokath stents (thermoexpandable) determines the ease with which they are positioned and especially extracted.

Regarding the results of using metallic stents in malignant ureteral strictures, the data are difficult to analyze (due to the different constructive types and the inhomogeneous groups studied). In a recent study, Lee et al. (2006) report the 9-year experience regarding thermoexpandable ureteral stents. Thus, at approximately 45 months from insertion, 50% of stents were functional, while 27% presented encrustations with secondary obstruction. In cases with ureteral stenosis after radiotherapy, a progressive alteration of renal function was recorded, although the stent remained functional throughout the entire follow-up period. The author concludes that metallic ureteral stents can be used with a good efficiency over long periods of time, of over 8 years. However, they are not permanent, and for this reason all patients must be monitored, especially those with secondary strictures after radiotherapy in whom the rate of complications (encrustation and migration) is higher. Most authors describe minimal immediate postoperative complications after the insertion of metallic ureteral stents: abdominal discomfort, urinary infections, and hematuria (Daskalopoulos et al., 2001). Urothelial hyperplasia with affection of the stent's lumen is a relatively common phenomenon, observed in most stents with the exception of Memokath 051-type stents (Hekimoglu et al., 1996). There are very few studies addressing the influence of metallic stents on ureteral peristalsis. Hekimoglu et al. (1996) report complete inhibition of the peristaltic waves, while other authors (Daskalopoulos et al., 2001) support the presence of normal peristalsis at the level of the ureter located proximal and distal to the stent.

The postoperative follow-up of patients in whom thermoexpandable metallic stents have been inserted consists of simple reno-vesical radiography (performed on the first postoperative day for confirming the correct positioning of the stent) (Fig. 9.39) and renal sonography (repeated on the first and second postoperative day).

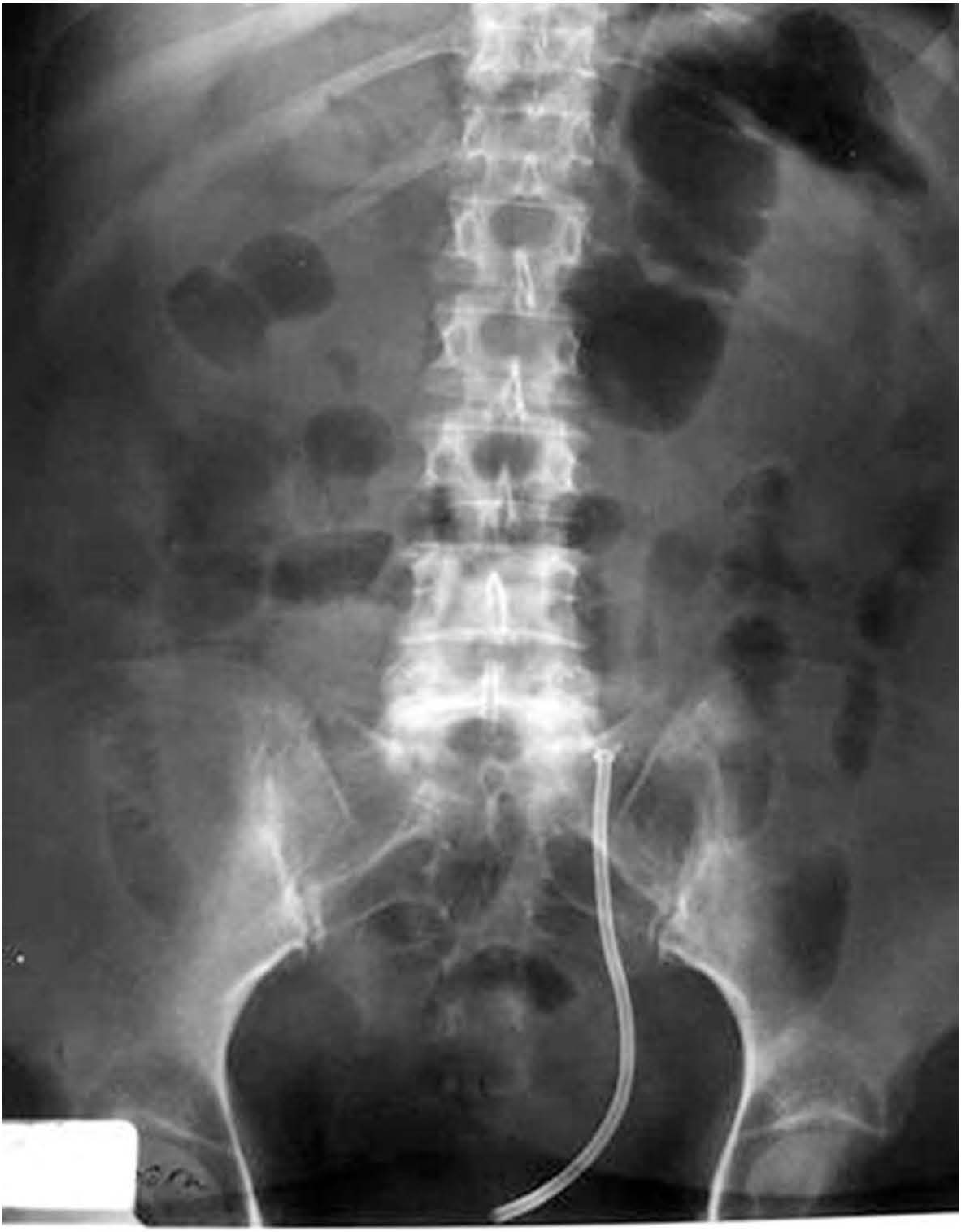

Figure 9.39 Left ureteral metallic stent (control simple reno-vesical radiography).

The serum creatinine levels will be determined on postoperative days 1, 3, and 7, then each month during the first 3 months, and subsequently every 3 months throughout the entire follow-up period. Ultrasonographic exam and uroculture are necessary at 1, 2, 4, and 6 months after the intervention, and then every 3 months. In cases with normal renal function, intravenous urography is indicated at 1 and 6 months after the stent's insertion. In selected cases, renal scintigraphy with isotopic nephrogram or ureteroscopy may be necessary (for cases with encrustations).

The introduction of this type of stent into practice offers an alternative to patients with urinary tract obstructions that would have required temporary drainage, replaced periodically, and sometimes invalidating definitive nephrostomies.

Chapter 10

Abstract

Ureteropelvic junction (UPJ) stenosis is defined as the deficiency in urine transportation from the pyelocaliceal system toward the proximal ureter. Its presence leads to the dilation of the pyelocaliceal system with potentially severe consequences for the kidney. The etiology of these stenoses is not completely known, being congenital or secondary to a medical act. UPJ stenosis is the most common cause of neonatal hydronephrosis.

Keywords

ureteroscopic pyelolysis
ipsilateral renal function
laparoscopic pyeloplasty
endopyelotomy
stenotic junction
cold-knife
laser fiber incision
electrocautery
pyelostent

10.1. Generalities

Ureteropelvic junction (UPJ) stenosis is defined as the deficiency in urine transportation from the pyelocaliceal system toward the proximal ureter. Its presence leads to the dilation of the pyelocaliceal system with potentially severe consequences for the kidney (Fig. 10.1).

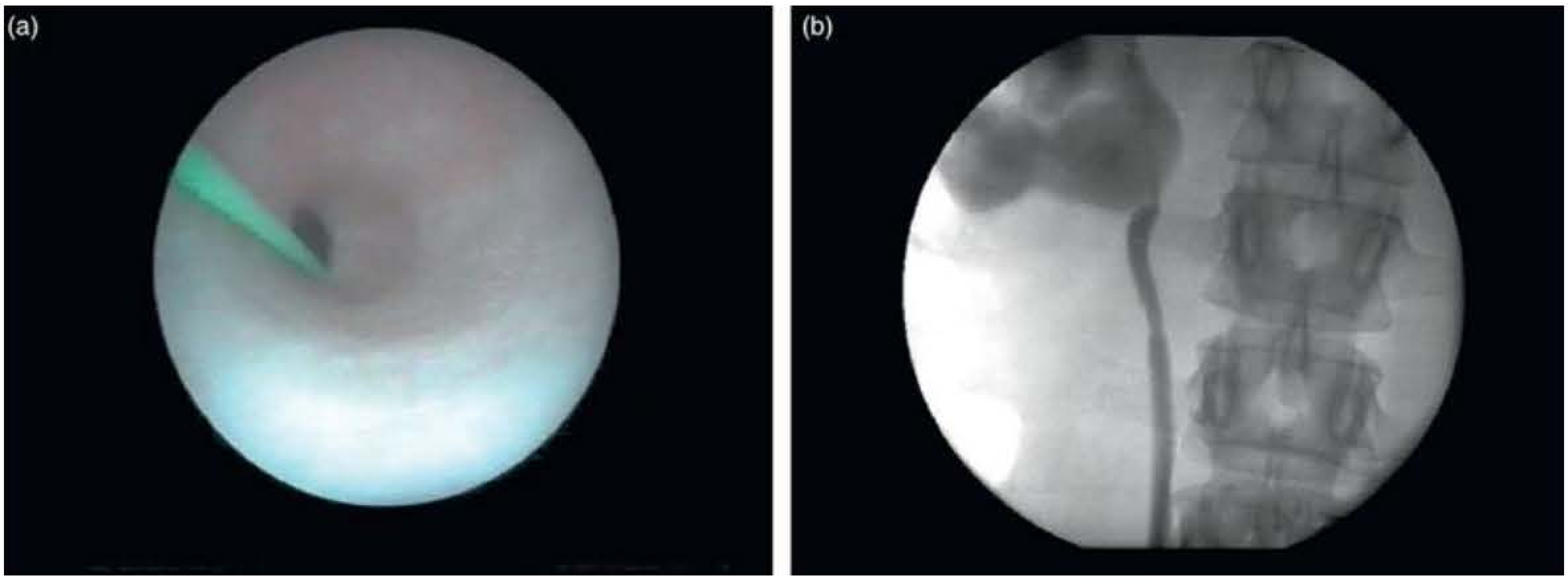

Figure 10.1 Right UPJ stenosis.

(a) Endoscopic and (b) pyelographic aspect.

The etiology of these stenoses is not completely known, being congenital (Fig. 10.2) or secondary to a medical act (Fig. 10.3). UPJ stenosis is the most common cause of neonatal hydronephrosis. According to the EAU guidelines, its overall incidence is 1:5000 neonates, the ratio between male and female gender being 2:1 (Tekgul et al., 2007).

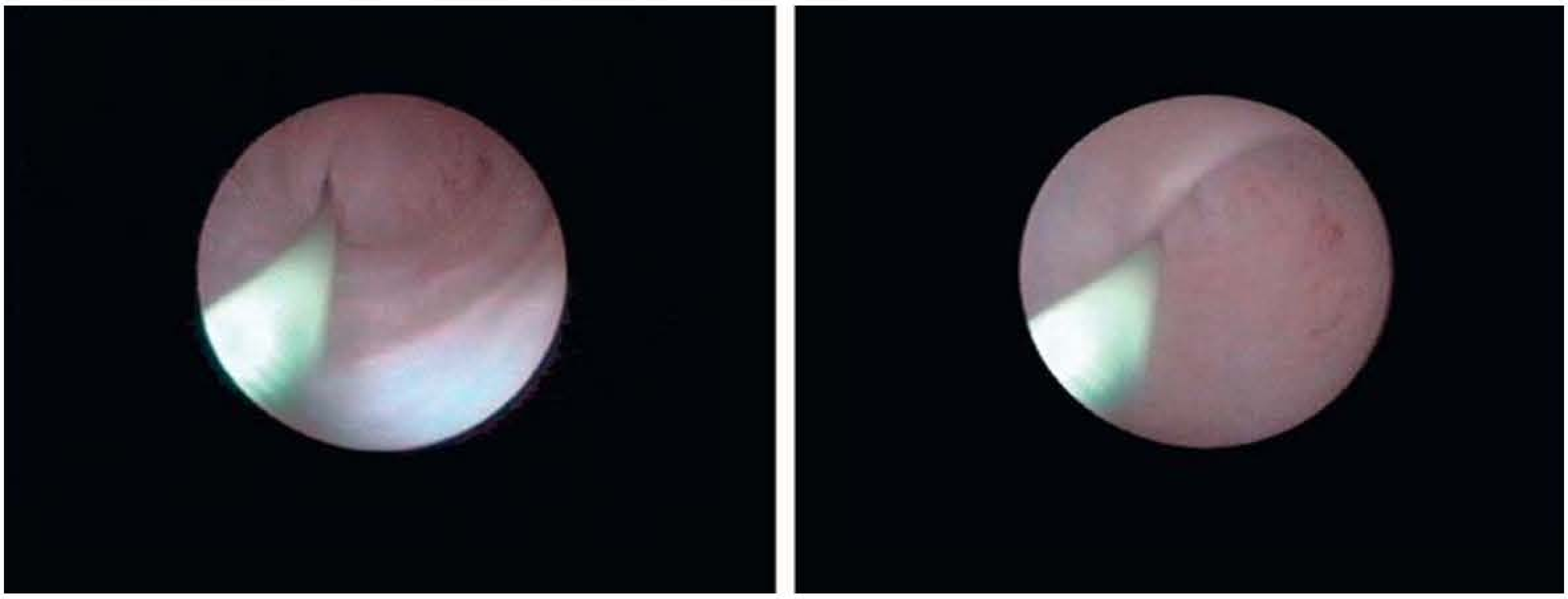

Figure 10.2 Endoscopic aspects of primary UPJ stenosis.

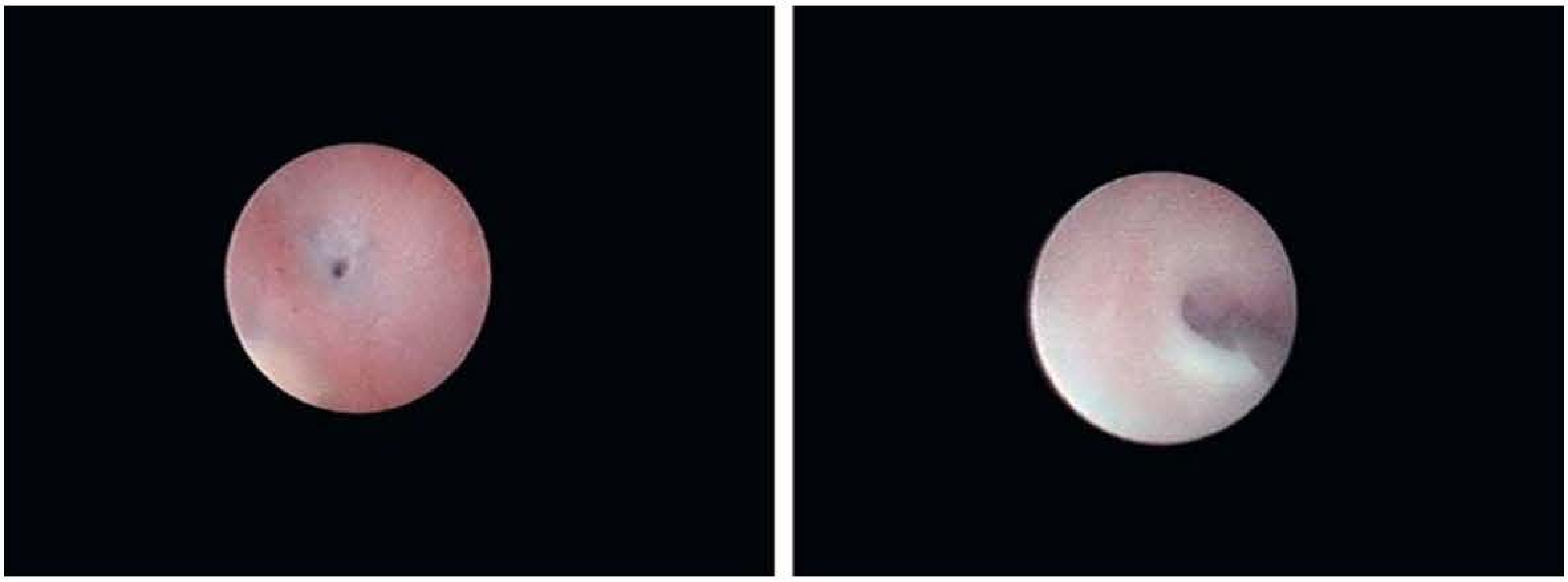

Figure 10.3 **Endoscopic aspects of secondary UPJ stenosis.**

The management of upper urinary tract obstruction, as a pathological entity, has been marked by technological progress both in terms of diagnosis and especially of treatment. The first attempt of a surgical treatment in UPJ stenosis belonged to Trendelenburg in 1886, while the first endoscopic intervention was carried out by Albarran in 1903, using an external endopyelotome. In 1983, Wickham and Kellet first described ureteroscopic pyelolysis, and in 1986, Inglis and Tolley reported their personal experience regarding this method. The presented data described a small number of cases in which the intervention was performed using rigid or flexible ureteroscopes and a 3–5 F cutting electrode, the incision being performed under direct visual control (Inglis and Tolley, 1986). In 1985, Bagley imagined a combined percutaneous and ureteroscopic procedure for the management of UPJ obstruction.

In 1996, Thomas performed the first studies on preoperative ureteral endoprosthesis in order to facilitate the ureteroscopic passage during retrograde endoscopic treatment (Poulakis et al., 2004; Thomas et al., 1996). A new concept of retrograde endopyelotomy, carried out in a single step, was described by Soroush and Bagley (1998).

The retrograde incision of the stenosed junction using an Acucise™-type device (Applied Urology, Rancho Santa Margarita, CA) was initially reported in 1993 by Chandhoke. The various modalities of antegrade or retrograde endoscopic treatment follow the principle of "intubated ureterotomy" stated by Davis in 1943. The procedure consists of the endoscopic incision of the UPJ up to the proximal ureter, with a depth that allows the exposure of the peripyelic and periureteral fat or, in case of secondary stenosis, to pass the area of periureteral fibrosis. After performing the incision, a stent is placed for modeling. Endopyelotomy can be antegrade, by percutaneous approach, or retrograde, by ureteroscopic approach.

The retrograde technique, which is currently being used more and more frequently, has a well-documented efficiency, its success rate being equivalent with percutaneous procedures in selected cases. Modernly, due to the lower caliber instruments, the single-step approach of the UPJ stenosis is considered standard.

10.2. Indications

UPJ stenosis may become clinically manifest during midlife or even later. Sometimes the patient is asymptomatic and the obstruction can only be objectified by a series of studies. However, all diagnosed patients can benefit from reconstructive procedures (Jacobs et al., 1979; O'Reilly, 1989). They are indicated, regardless of age, when signs of global or ipsilateral renal function impairment appear (Kumar et al., 1988).

Currently, UPJ stenosis benefits from multiple treatment modalities. Most authors still consider open surgical pyeloplasty to be the "gold standard" of therapy for this pathological entity. The development of minimally invasive techniques in recent years has increasingly brought retrograde or antegrade endopyelotomy and laparoscopic pyeloplasty into the spotlight (Geavlete et al., 2002a).

10.2.1. Therapeutic Indications for UPJ Stenosis

The modern indications for treatment in UPJ stenosis are represented by the following:

- presence of symptoms associated with obstruction
- alteration of global renal function
- progressive alteration of ipsilateral renal function
- presence of associated lithiasis
- presence of urinary infection
- presence of hypertension (in rare cases)

Surgical intervention has the purpose of creating a normal, nonobstructive urinary flow, the ultimate goal being the improvement of the renal function (Fig. 10.4).

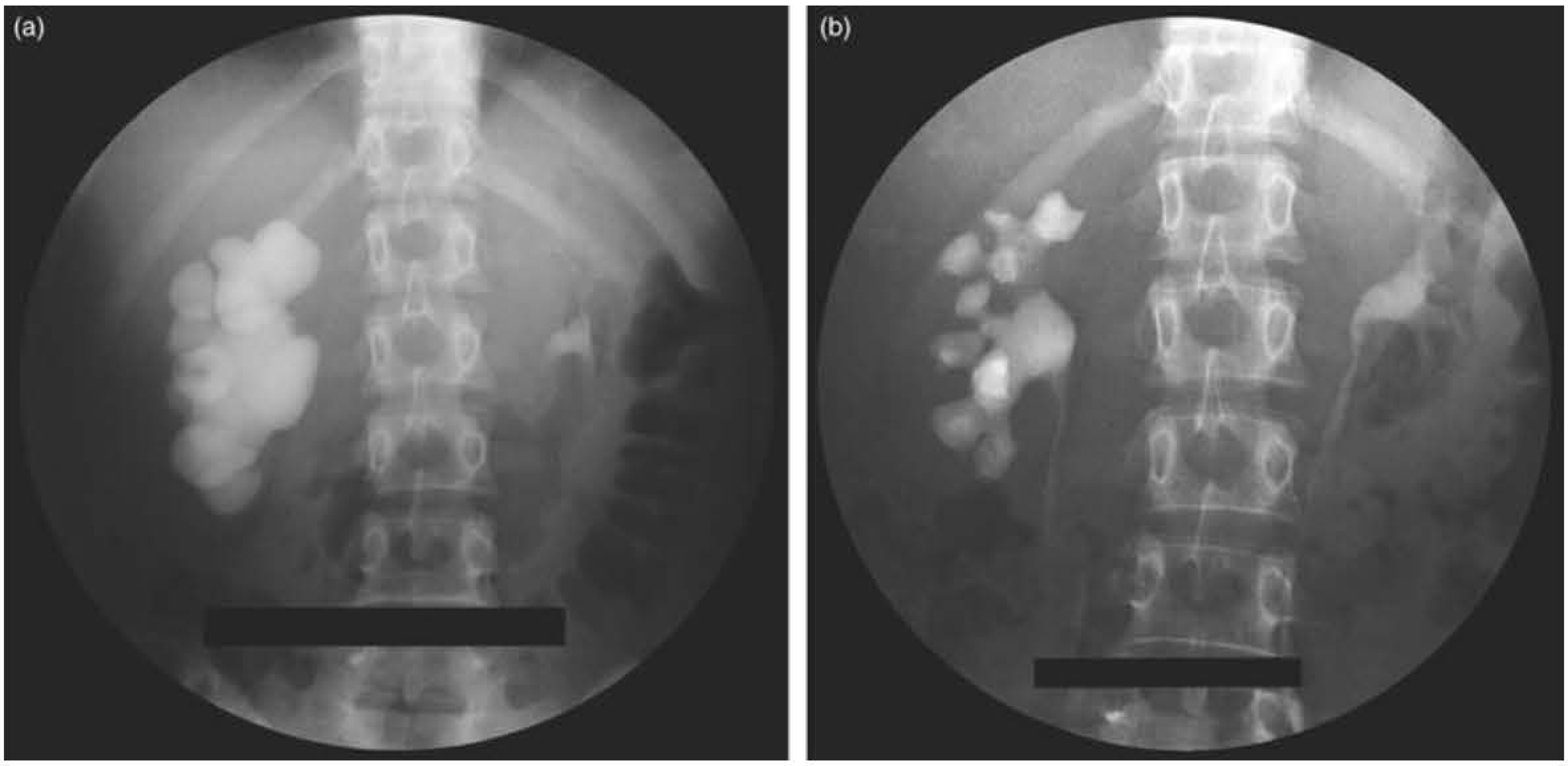

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Figure 10.4 **Preoperative (a) and postoperative (b) radiologic aspect of the upper urinary tract in a patient with UPJ stenosis (IVU).**

In general, early intervention is recommended for neonates and children in order to preserve the renal function (Walsh et al., 2002). However, the optimal moment for the intervention remains controversial in neonates due to the possibility of the presence of a functional-type obstruction (Koff, 1998; Hanna, 2000).

In a prospective study conducted on a group of 104 neonates with unilateral hydronephrosis, probably due to a congenital UPJ stenosis, it was found that only 7% of cases required pyeloplasty as a consequence of hydronephrosis progression or of a 10% decrease of the glomerular ultrafiltrate (Koff and Campbell, 1994). Renal function returned to normal values after the intervention in all these cases.

10.2.2. Therapeutic Options in UPJ Stenosis

The last century saw a continuous progress and diversification of the therapeutic options reserved for UPJ stenosis (Table 10.1). Open surgical intervention (pyeloplasty) is a reconstructive type of surgery. While the first attempt dates back to 1886 (Trendelenburg), the first successful pyeloplasty was only performed in 1891 by Kuster. Changes to the technique, which included the use of a flap, were introduced in 1916 by Schwyzer, while Y–V pyeloplasty was modified by Foley in 1937.

Table 10.1

Therapeutic Alternatives in UPJ Stenosis

Retrograde endoscopic techniques	1. Balloon dilation 2. Endopyelotomy with the Acucise catheter 3. Retrograde endopyelotomy using a rigid or flexible ureteroscope and a. Cold knife b. Ureteroresectoscope c. Holmium:YAG laser
Antegrade endoscopic techniques	Antegrade endopyelotomy using 1. Cold knife – "classic" 2. Electrocautery – Collins loop 3. Holmium:YAG laser
Laparoscopic techniques	Laparoscopic pyeloplasty
Open surgical techniques	Open surgical pyeloplasty

In 1949, Hynes and Anderson described a modified technique that involved the anastomosis of the spatulated ureter at one end of the renal pelvis after the resection of the excess segment, a procedure that still has a wide applicability today.

Laparoscopic techniques allow for an accurate reproduction of an open surgical intervention. The major advantage of laparoscopy is the minimally invasive approach, with minimal operative trauma, rapid recovery, and short hospitalization.

Also, the laparoscopic approach allows for the transposition of the polar vessels at the level of the junction. However, in secondary UPJ stenosis, the laparoscopic procedure can be more difficult due to peripyelic and periureteral fibrosis.

One of the variants of this method is the robot-assisted procedure, which has the advantage of precise movements (with more degrees of freedom than traditional laparoscopy) and of a three-dimensional visualization of the workspace. Due to these characteristics, the duration of achieving the intracorporeal anastomoses and, in the end, the operating time, can be reduced. Currently, the operating time for a laparoscopic intervention is comparable to that of an open surgical intervention.

Regarding the endoscopic techniques, direct visual inspection of the stenotic area and interactively determining the site of incision are possible during the procedure. The results published in the literature prove that endopyelotomy can be a viable alternative in the treatment of UPJ stenosis. The desire to improve the surgical techniques in order to achieve higher success rates has led to combinations between endoscopic and laparoscopic techniques. These consist of the longitudinal endoscopic incision followed by the transverse suture of the incision by a minilaparoscopic approach (Desai et al., 2004). The initial results of the technique are good, but the procedure requires the test of time in order to be adopted.

Although the success rates of the endoscopic procedures are percentually lower than those of traditional surgery, there are studies that claim these can be improved through a more judicious selection of patients.

Nephrectomy remains the only method of treatment if the kidney is urographically and scintigraphically nonfunctioning.

10.2.3. Indications for Retrograde Endoscopic Treatment in UPJ Stenosis

The individualization of treatment takes into account especially the ratio between risks and benefits, and the choice for one of the therapeutic alternatives must be discussed with the patient.

Although, theoretically, the retrograde ureteroscopic approach can be used in most cases of UPJ stenosis, the experience gained has allowed the adoption of some criteria that can optimize the results of these interventions. Impaired preoperative renal function, the length of stenosis, or severe hydronephrosis are considered to be negative prognostic factors.

Thus, in patients with differential ipsilateral renal function less than 20%, the drainage of the renal unit by placing a

JJ ureteral stent or a percutaneous nephrostomy can initially be recommended. Reassessment of the renal function represents the decisive element in choosing between a reconstructive treatment and excision (Nakada and Johnson, 2000).

A length of the stenotic area greater than 2 cm is a relative contraindication for retrograde endoscopic treatment, and these cases can benefit from open or laparoscopic pyeloplasty (Mendez-Torres et al., 2004).

Preoperative hydronephrosis is an important factor in choosing the approach because the size of the renal pelvis will remain unchanged in case of an endoscopic intervention. This is the reason why open or laparoscopic pyeloplasty (conventional or robot-assisted) is recommended in patients with important dilation of the pyelocaliceal system (Fig. 10.5) (Mendez-Torres et al., 2004).

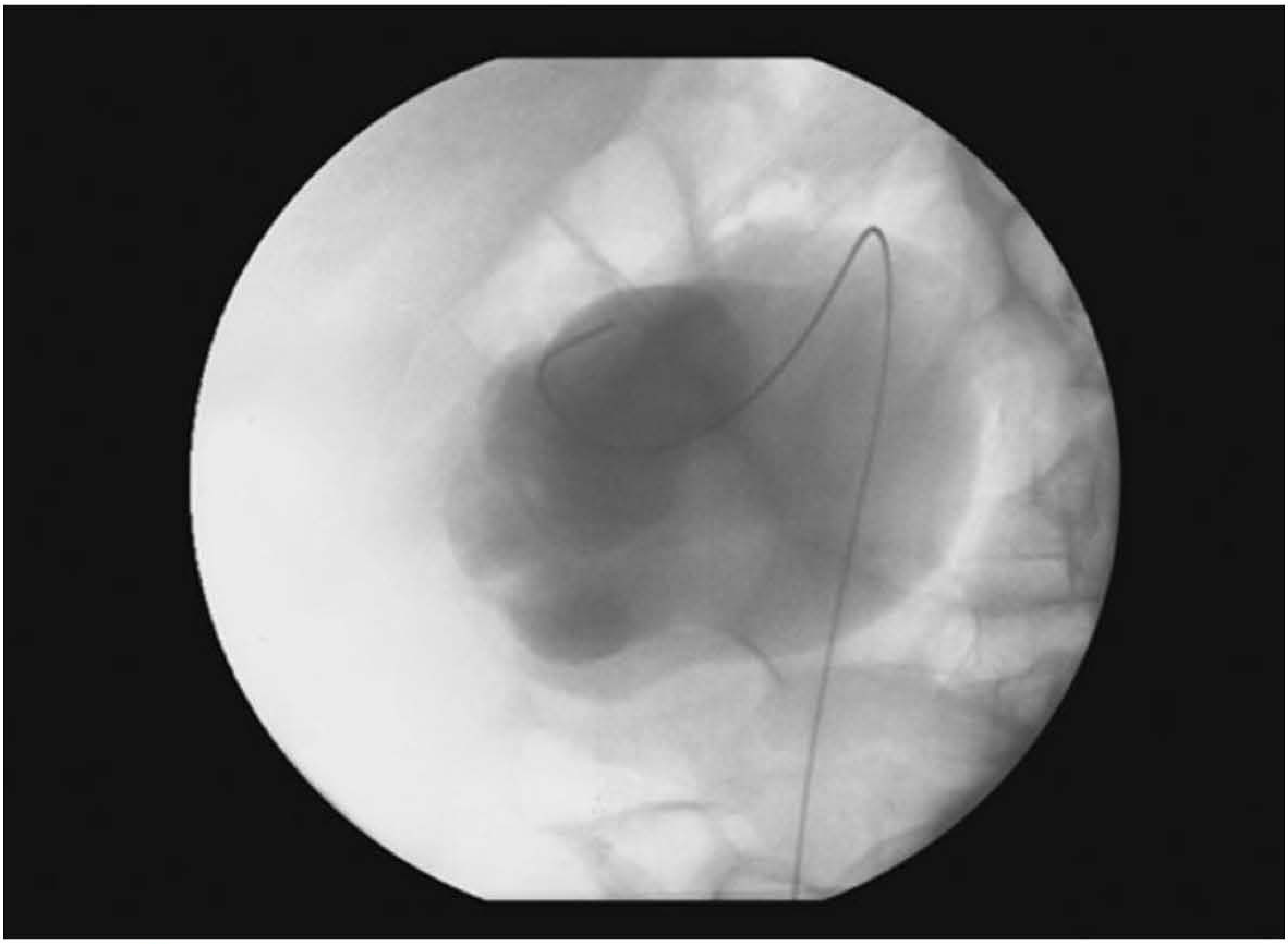


Figure 10.5 **Right UPJ stenosis, with grade IV hydronephrosis (retrograde pyelography).**

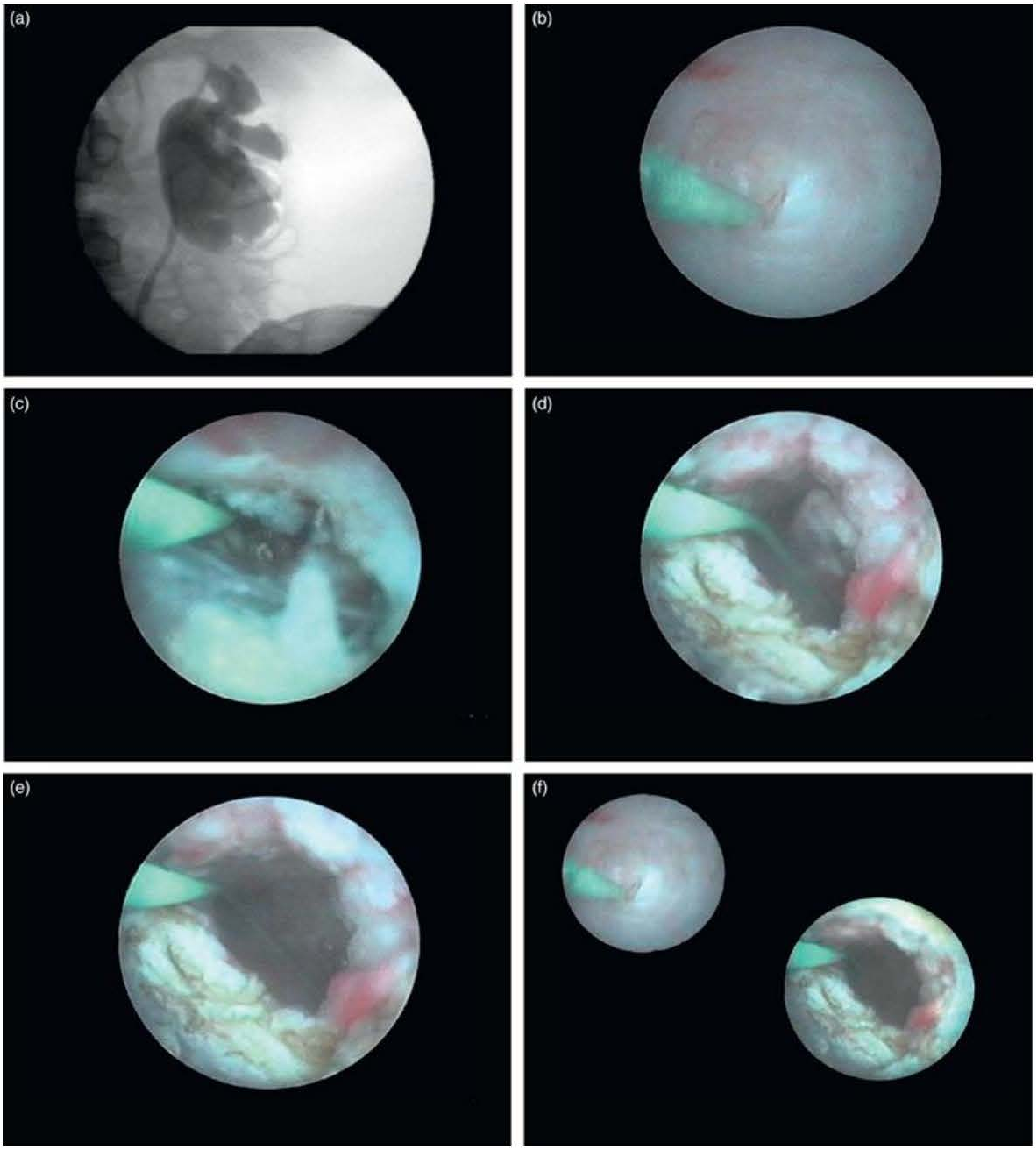
Although retrograde endopyelotomy under direct visual control can also be carried out in the presence of polar vessels, the success rate in such cases is relatively low, ranging between 32–53%, thus supporting the idea of selecting patients in order to improve the success rate (Parkin et al., 2003; Tan and Smith, 2004).

Imagistic evaluation has demonstrated the presence of polar vessels in 46–60% of cases (Quillin et al., 1996; Mitsumori et al., 2000).

Choosing the open or the laparoscopic approach offers the possibility of direct visualization of the polar vessels, thereby allowing UPJ translocation and performing a Hynes–Anderson-type pyeloplasty. In case of endoscopic approach, imagistic evaluation can preoperatively predict the intervention's outcome (Bagley et al., 1995; Braun et al., 2007).

Patients with UPJ stenosis and polar vessels represent the best indication for an open or laparoscopic surgical reconstructive therapy (Parkin et al., 2003).

The impact of the ureter's insertion site (Fig. 10.6) at the pyelic level on the results of endopyelotomy is still a controversial subject. Thus, while some authors believe that high insertion is associated with a reduction in the rate of success, thereby becoming a contraindication for the endoscopic approach, other studies did not identify this difference (Thomas, 1996; Shalhav et al., 1998).


(a)
(b)
(c)
(d)
(e)
(f)

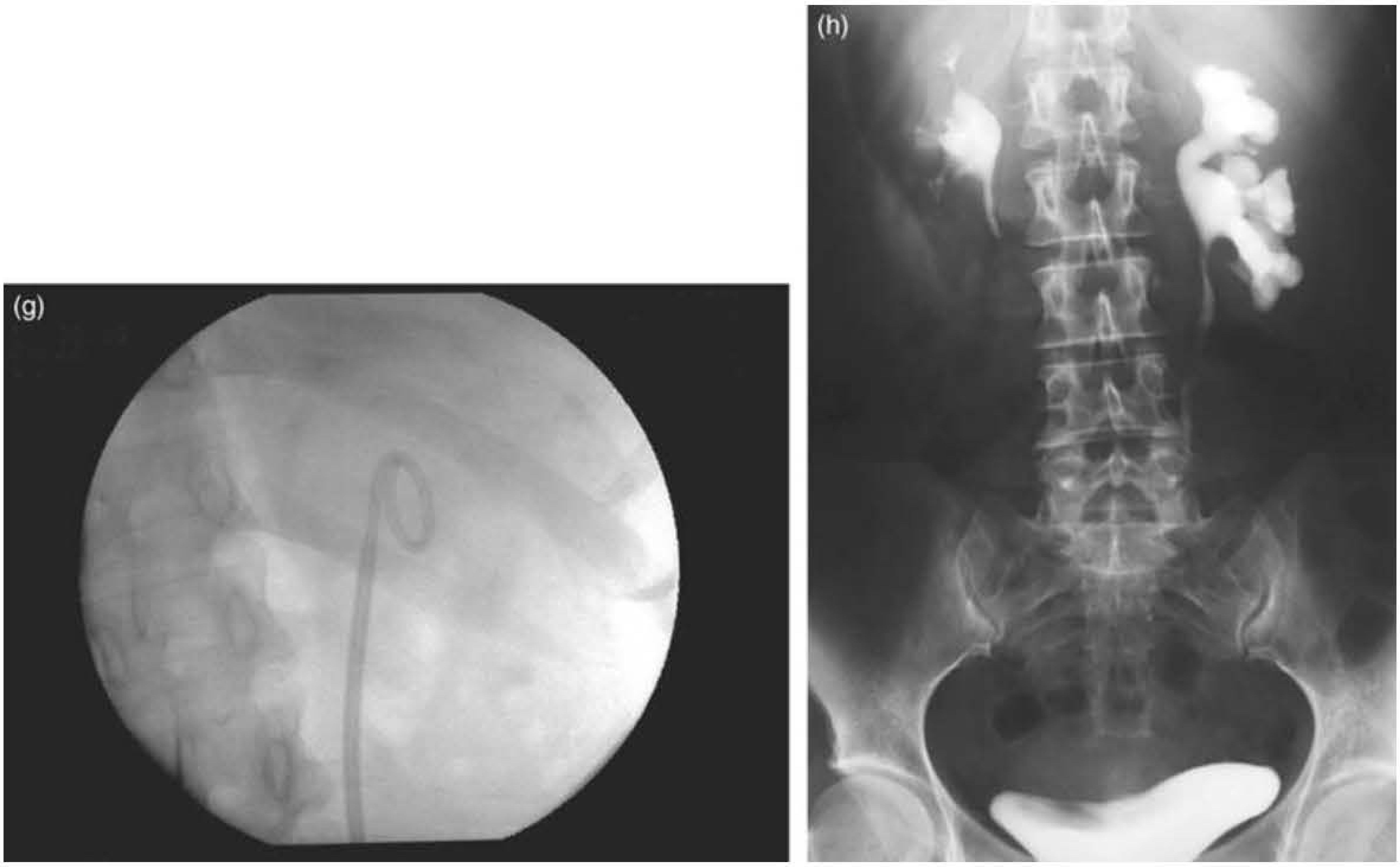


Figure 10.6 Retrograde ureteroscopic approach of a UPJ stenosis with high insertion of the ureter (a, b), laser incision (c–e), pre- and postoperative comparative aspect (f), correctly positioned pyelostent (g), wide UPJ at 3 months after intervention (h).

Association of renal lithiasis represents an indication for the antegrade approach in the detriment of the retrograde one, this attitude allowing both conditions to be solved in a single procedure. However, the development of modern flexible ureteroscopes with an increased reliability and the introduction of the Ho:YAG laser have transformed retrograde endopyelotomy associated with intracorporeal lithotripsy into a viable alternative in selected cases with low lithiasic mass.

The average success rates after primary retrograde endopyelotomy or after open interventions are relatively similar, and a failed retrograde intervention does not seem to adversely affect the results of consecutive pyeloplasty (Geavlete et al., 2004, 2006). On the other hand, the results of iterative endopyelotomy are modest (Ng et al., 2003).

This is why some authors propose pyeloplasty if the endoscopic procedures fail, respectively endopyelotomy in case of the recurrence of the stenosis operated by open surgery. In this type of “secondary” UPJ stenosis, endopyelotomy is a viable alternative with a success rate that may reach 87.5% (Jabbour et al., 1998; Hoenig et al., 1998; Geavlete et al., 2001a,b, 2002b; Levin and Herrell, 2006).

Another factor that may determine modest postoperative results is represented by the reduced production of growth factors (Liatsikos et al., 2001).

Balloon dilation of UPJ stenosis was first performed in the 1980s. However, due to the low success rates, this method has lost popularity.

Although the incidence of complications was very low and the success rate was initially encouraging, these were quickly overshadowed by the very high percentage of restenoses. The method was abandoned after a short period due to the fact that the mere dilation of the affected segment does not allow the regeneration of healthy tissue.

10.3. Retrograde endopyelotomy technique

10.3.1. Preliminary Measures

The preoperative evaluation should include paraclinical investigations, which can document the presence of the UPJ organic stenosis, as well as its morphofunctional consequences, with direct implications on the therapeutic option.

The investigational protocol may include renal ultrasonography, IVU, renal scintigraphy (Fig. 10.7), the Whitaker test, and, in order to identify possible polar vessels, spiral CT or endoluminal ultrasonography (Fig. 10.8) (Mendez-Torres and Thomas, 2007).

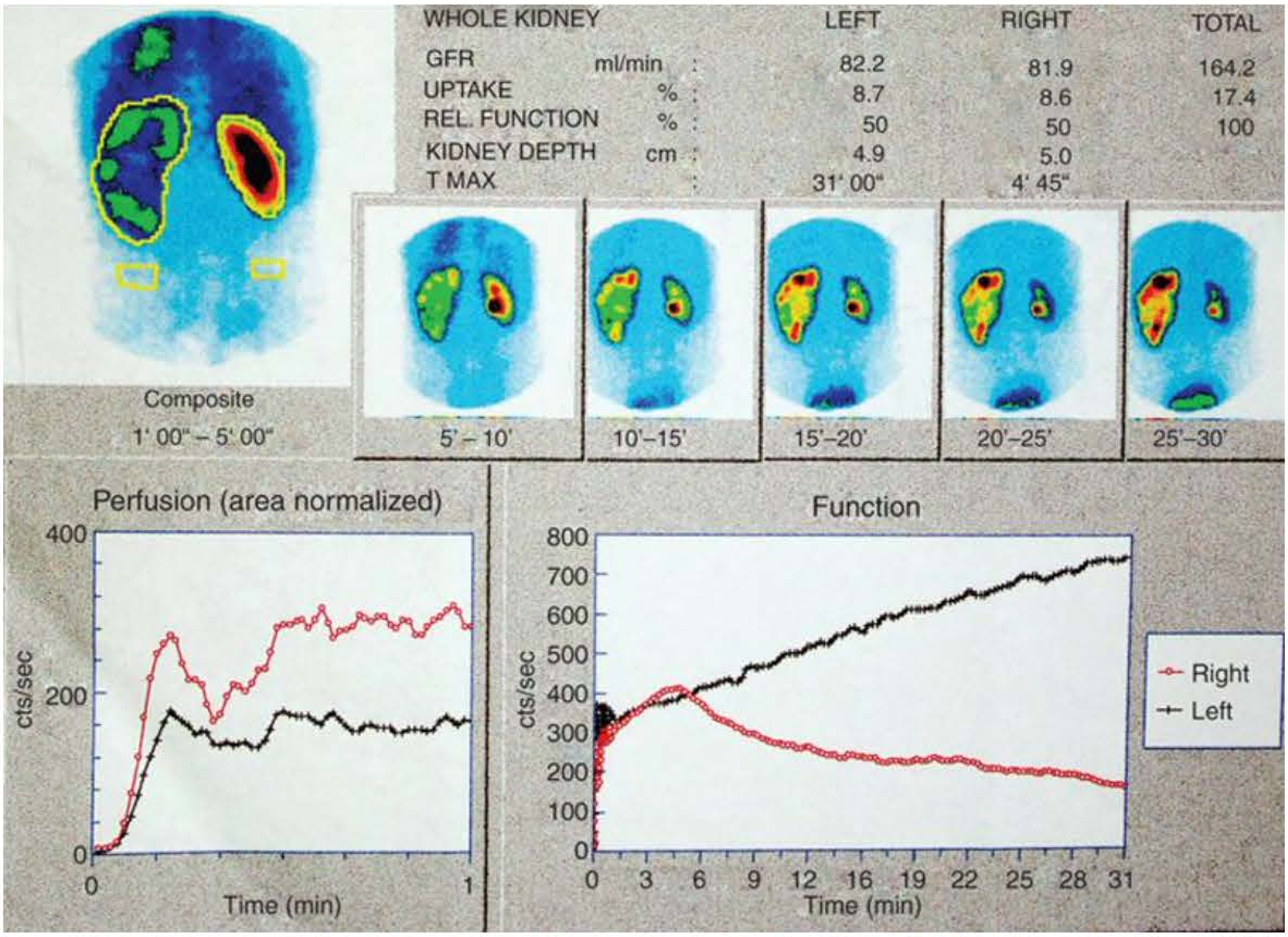

WHOLE KIDNEY
LEFT
RIGHT
TOTAL
GFR ml/min : 82.2 81.9 164.2
UPTAKE % : 8.7 8.6 17.4
REL. FUNCTION % : 50 50 100
KIDNEY DEPTH cm : 4.9 5.0
T MAX : 31' 00" 4' 45"
Composite
1' 00" – 5' 00"
5' – 10'
10'–15'
15'–20'
20'–25'
25'–30'
Perfusion (area normalized)
400
200
0
cts/sec
0
1
Time (min)
Function
800
700
600
500
400
300
200
100
0
cts/sec
0
3
6
9
12
16
19
22
25
28
31
Time (min)
Right
Left

Figure 10.7 Renal scintigraphy with isotopic nephrogram in a patient with left UPJ stenosis.

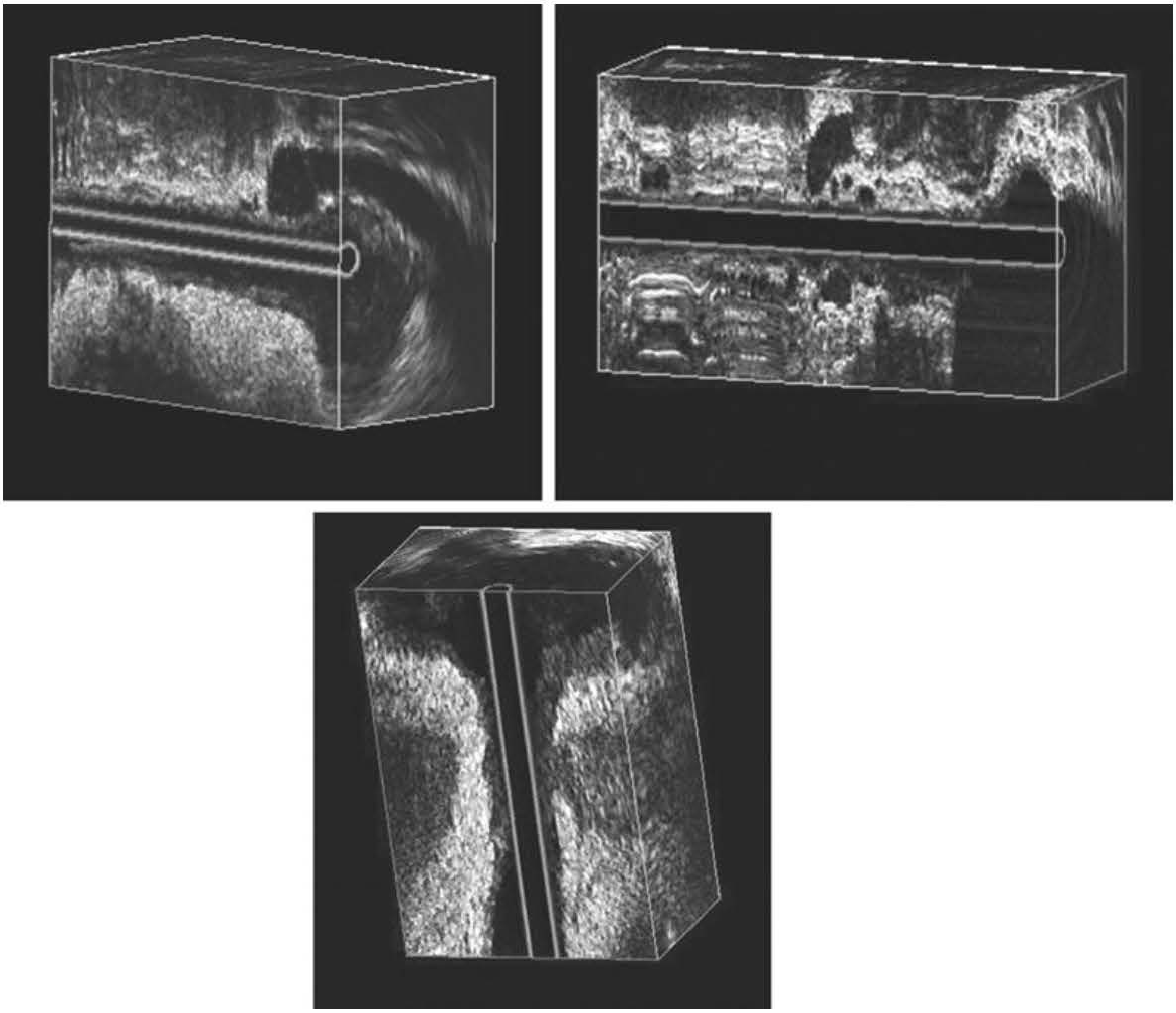


Figure 10.8 **UPJ evaluation by 3D endoluminal ultrasonography.** Source: With permission from Liu (2006).

An important step in the preoperative preparation of patients is the antibiotic prophylaxis of common uropathogens.

Retrograde endopyelotomy under direct visual control is performed under spinal or general anesthesia. The latter has the advantages of controlling breathing and of avoiding sudden movements that can lead to severe traumatic complications.

Sometimes, under spinal anesthesia, due to the dilation caused by the irrigation fluid, the patients may experience lumbar pains, especially if the anesthesia was carried out at a lower metameric level.

The intervention is performed in the classic lithotomy position.

The instruments needed include appropriate endoscopes, energy sources, and accessories, with some differences according to the type of incision (Table 10.2).

Table 10.2

Instruments Necessary for the Retrograde Approach of UPJ Stenosis

Cystoscope	Bladder inspection, retrograde ureteropyelography
Fluoroscope	Intraoperatory monitoring, placing the pyelostent
Ureteroscope	Semirigid, flexible, rigid ureteroresectoscope
Energy sources	Electrosurgery source, Ho:YAG, Nd:YAG
Accessory instruments	Guidewires, fulguration electrodes, Acucise catheter, ureteral catheters for electric insulation, endopyelotomy knife

10.3.2. Cystoscopy and Placement of Guidewires

After the cystoscopic evaluation of the bladder, which is a compulsory stage during each retrograde endoscopic intervention, RUP is performed (Fig. 10.9).

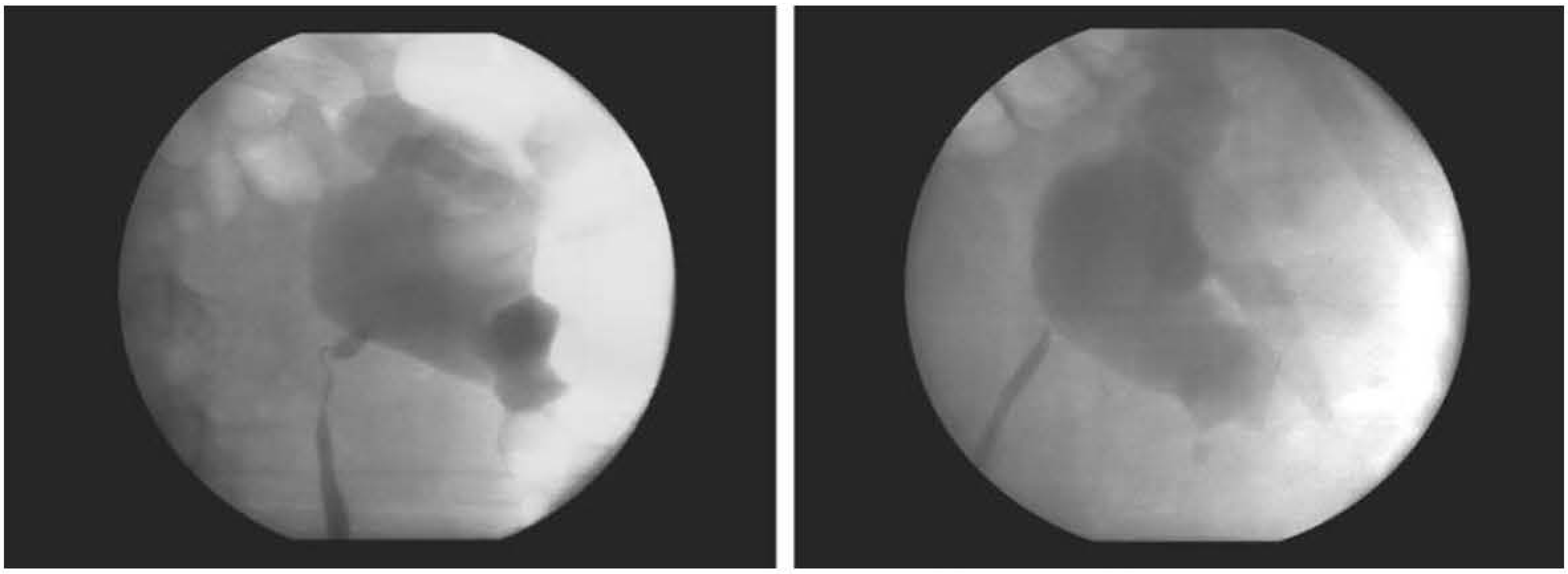


Figure 10.9 **Radiological aspects of UPJ stenosis (retrograde ureteropyelography).**

This will document the presence of the organic UPJ stenosis, its length, the ureter's insertion site at the pyelic level, and the possible associated ureteral or pyelocaliceal lesions.

Evaluation of the upper urinary tract by pyelography is also recommended in patients who underwent preoperative ureteral endoprosthesis, after removing the JJ catheter.

Subsequently, the safety guidewire will be placed, if possible, surpassing the area of stenosis at the UPJ level (Fig. 10.10). This safety guidewire will be maintained throughout the entire endoscopic intervention.

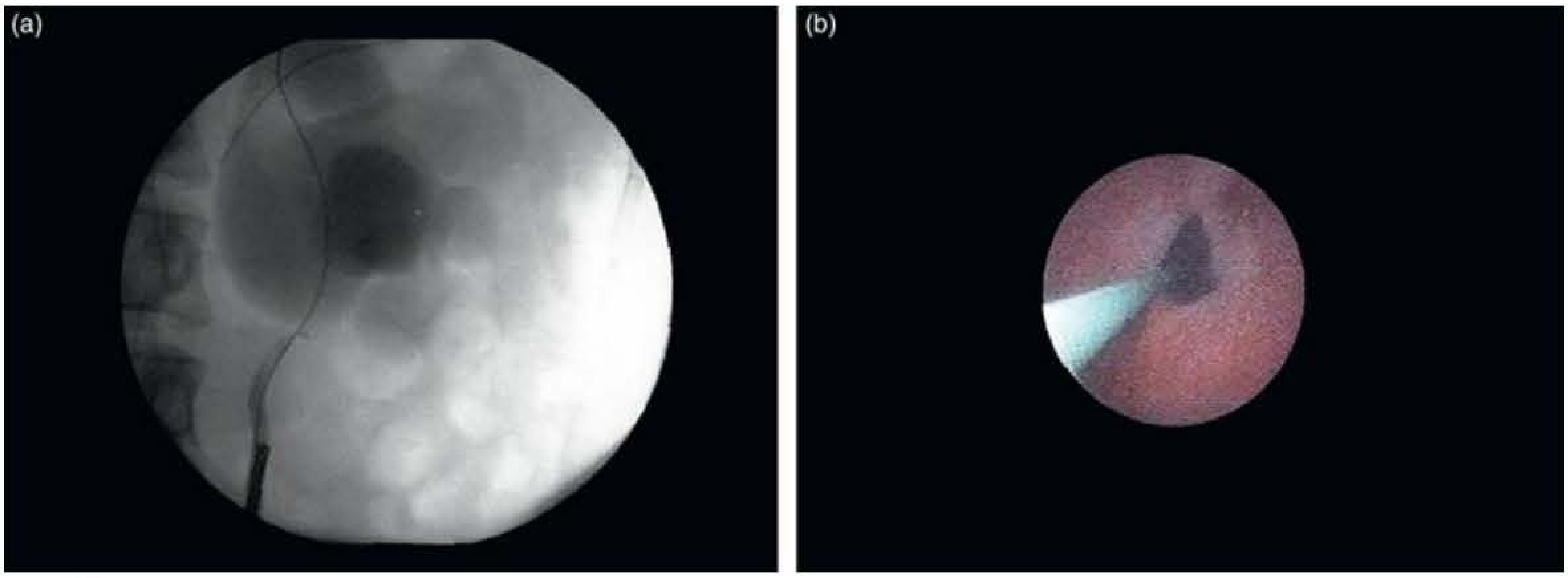


Figure 10.10 **Guidewire ascended up to the pyelocaliceal level (a), after surpassing the UPJ stenosis (b).**

In certain situations (tight stenoses, etc.), surpassing the UPJ with the guidewire is only possible ureteroscopically, under direct visual control (Fig. 10.11).

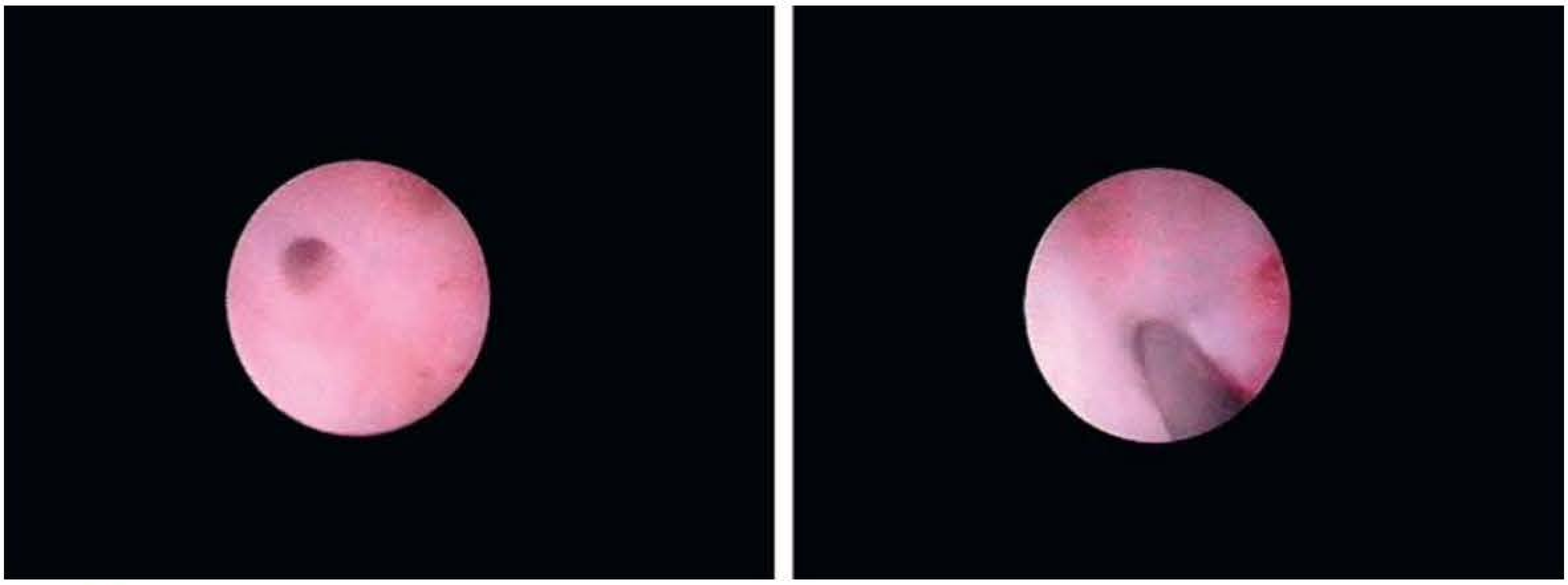


Figure 10.11 **Insertion of the guidewire at the level of the punctiform UPJ under direct visual control.**

10.3.3. Ureteral Access

The endoscopic approach of the UPJ stenosis can be achieved with rigid, semirigid, or flexible ureteroscopes, all with specific advantages and disadvantages, described in the previous chapters.

In case of a reduced diameter of the intramural ureter that does not allow for an easy passage of the ureteroscope, its dilation with the balloon catheter or with progressive ureteral dilation sets is indicated. In some cases, the ureteral orifice can be negotiated using two guidewires or pressurized irrigation systems (Uromat).

If the ureteral caliber is too small to allow the passage of the ureteroscope, a JJ catheter is placed and the intervention will be resumed after 5–10 days, during which passive dilation takes place.

The ureteroscope can be ascended on a second working guidewire or can be passed beside the safety guidewire, which was placed priorly (Fig. 10.12).

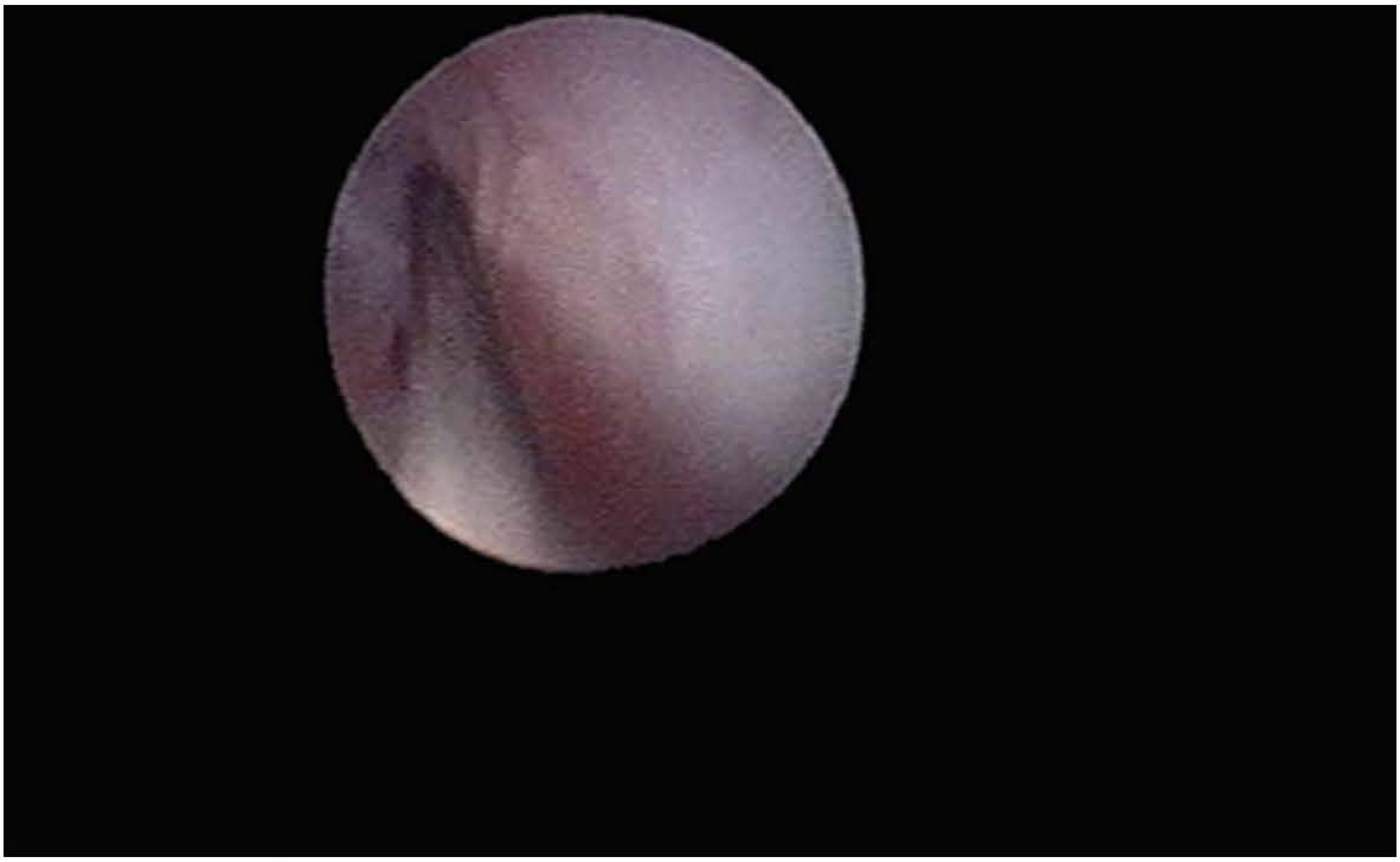


Figure 10.12 **Advancing the ureteroscope beside the safety guidewire.**

In men, the optimal approach of the UPJ is sometimes difficult, particularly due to the reduced mobility of the ureteroscope determined by its passage through the urethra.

In case of the impossibility of passing the ureteroscope through the junction, its dilation with a balloon catheter can be attempted.

10.3.4. Junction Incision

The incision of the stenotic junction will be preceded by a careful inspection of the segment in order to identify any pulsations at this level indicating the presence of polar vessels. It will be performed in the posterolateral segment, during the withdrawal movement of the ureteroscope (Fig. 10.13).

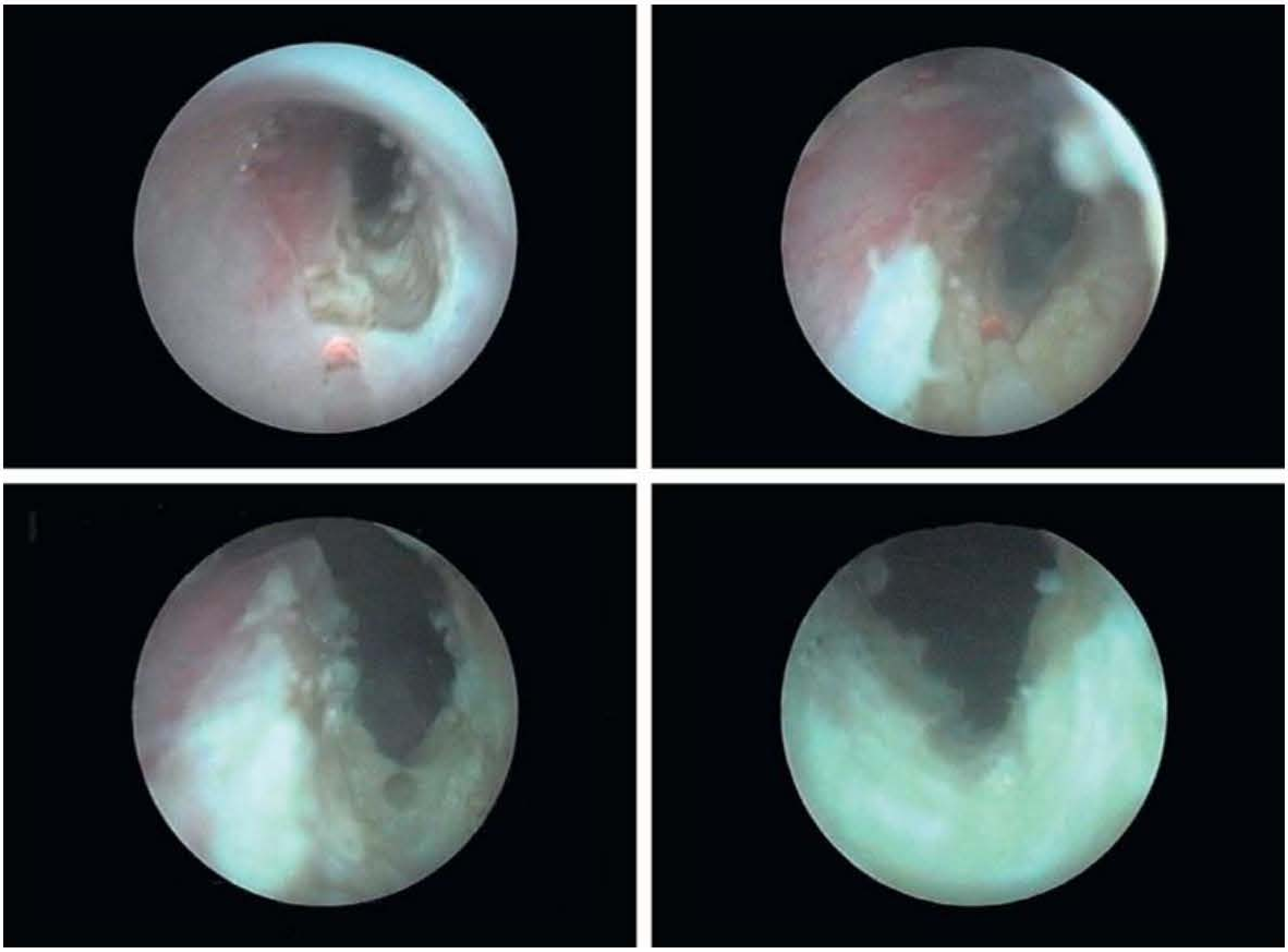


Figure 10.13 **Laser incision in the posterior region of the UPJ.**

The procedure is repeated until the peripyelic and periureteral fat from the retroperitoneal space is clearly exposed (Fig. 10.14), respectively until the area of fibrosis is completely passed in case of secondary stenosis (Fig. 10.15). The incision should be made until an adequate diameter of the junction is obtained, allowing for the easy ascent of the ureteroscope.

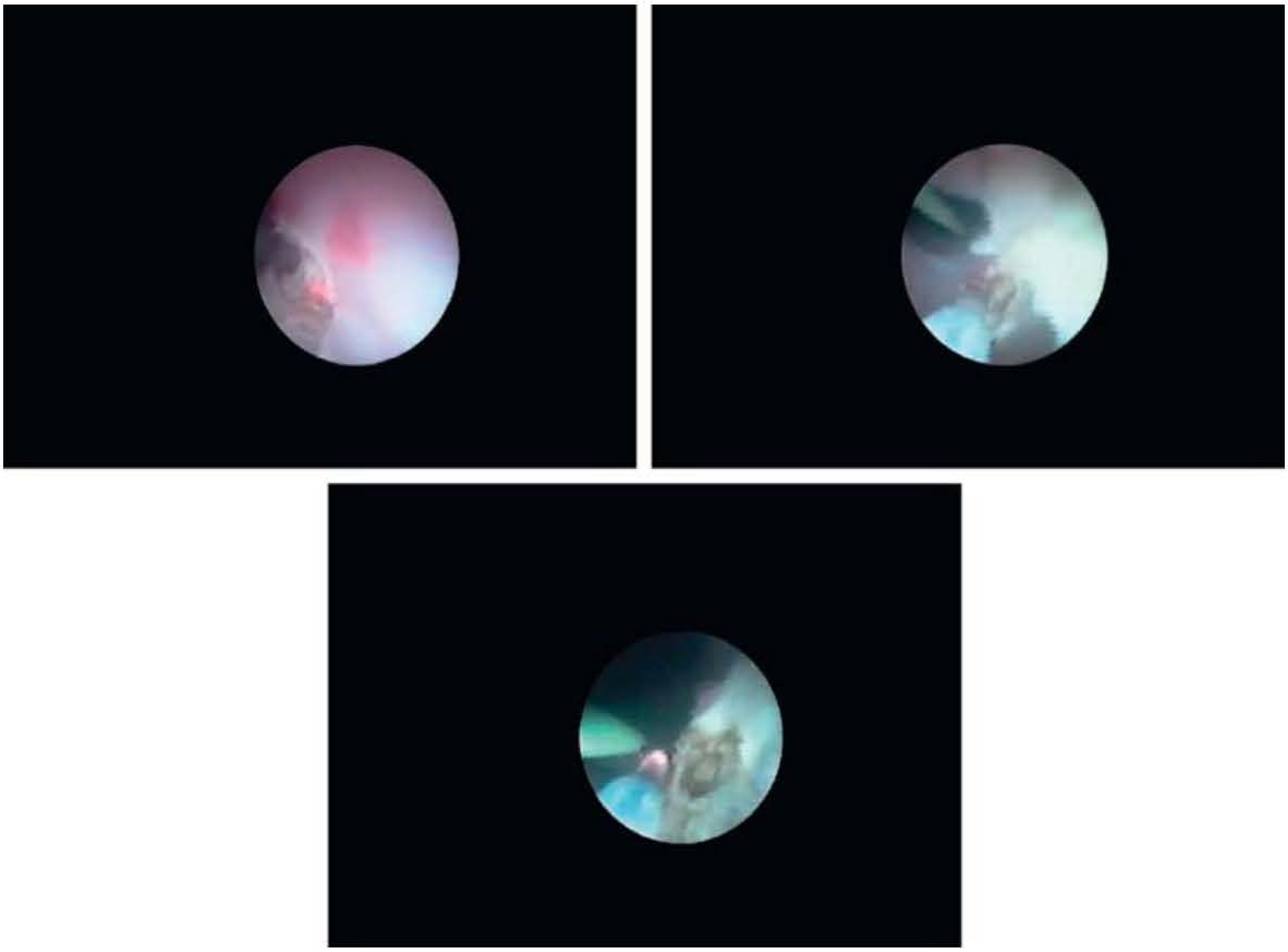


Figure 10.14 Laser incision of a primary UPJ stenosis, until the periureteral fat is clearly exposed.

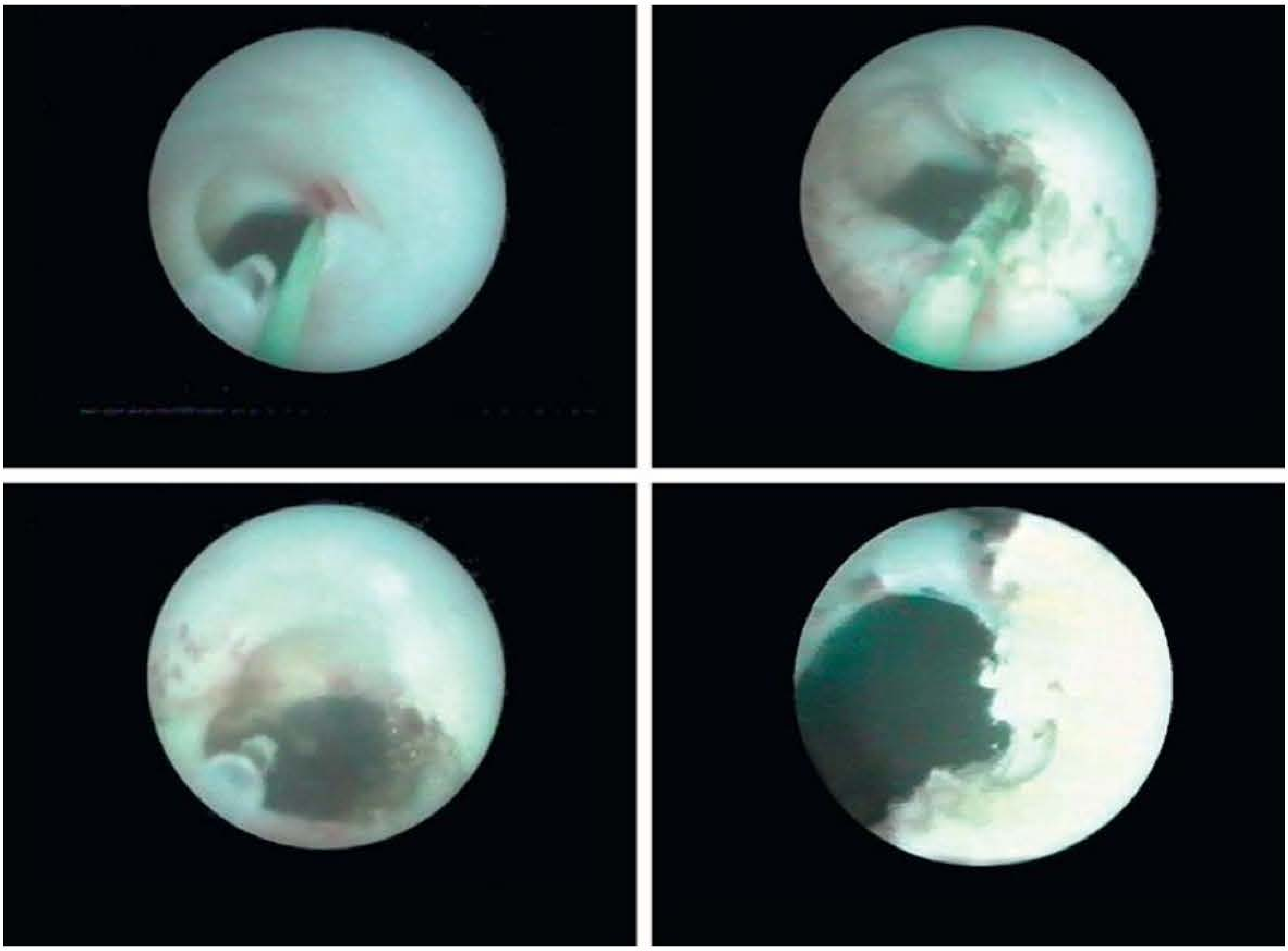


Figure 10.15 **The laser incision of a recurrent UPJ stenosis, until the area of fibrosis is passed.**

The incision is done distally until normal ureteral mucosa is reached. The classic technique recommends sectioning the junction area up to 1 cm distal to the stenosis itself, which creates the conditions for optimal healing, with minimal risk of restenosis.

The radiological control of a correct technique involves objectifying the leakage of the contrast agent that was injected through the ureteroscope (Fig. 10.16). Although performing a pyelography at the end of the intervention is not absolutely necessary, the maneuver is useful for confirming the complete incision of the stenotic area.

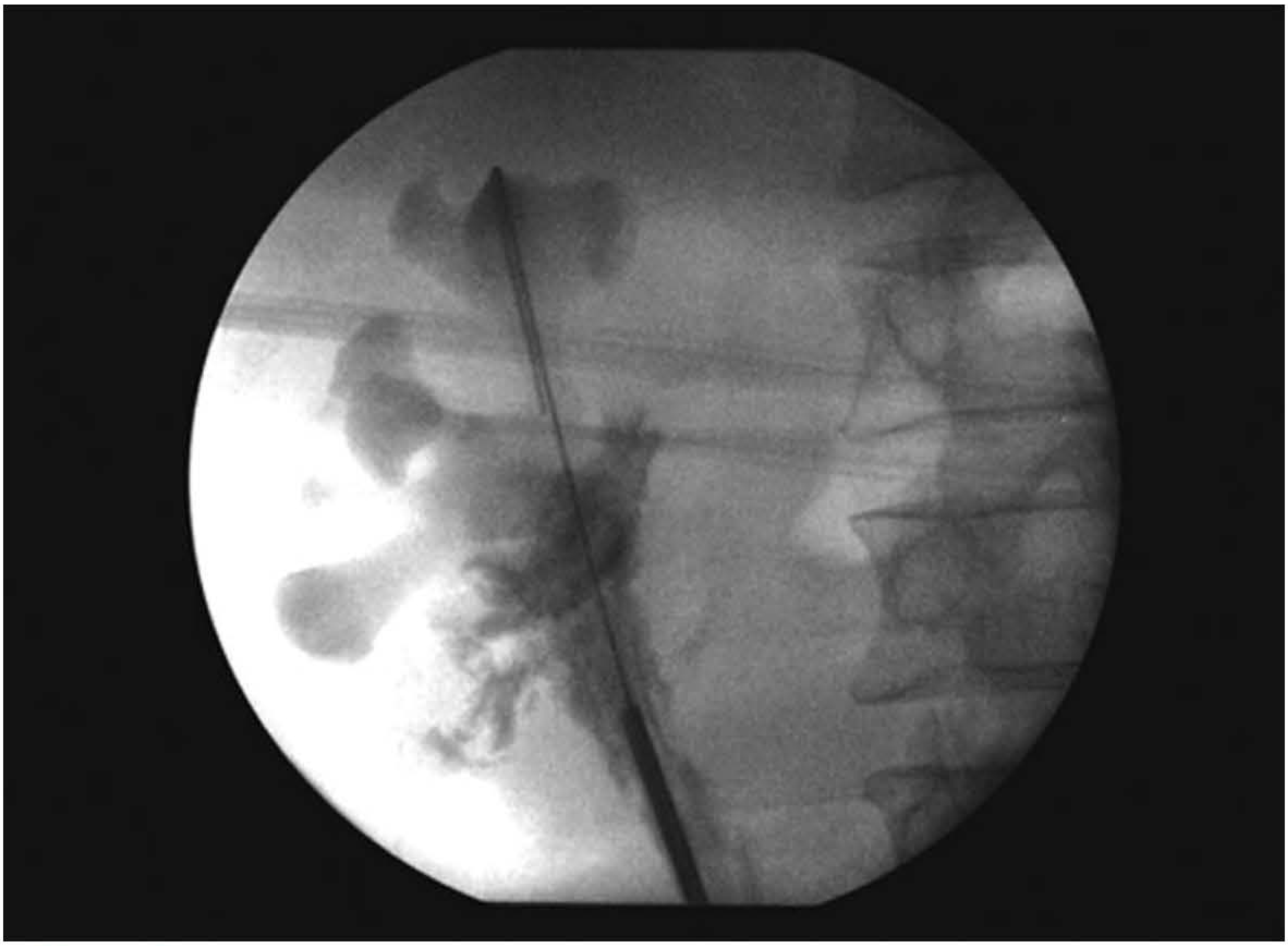


Figure 10.16 **Leakage of the contrast agent in retrograde pyelography, confirming a correctly done incision.**

The incision of the stenotic UPJ can be done using the following:

- the “cold-blade” knife
- laser fiber
- incision electrodes

10.3.4.1. Cold-Knife Endopyelotomy

The procedure is similar to an optical urethrotomy, but uses “scissors”-type knives (Fig. 10.17).

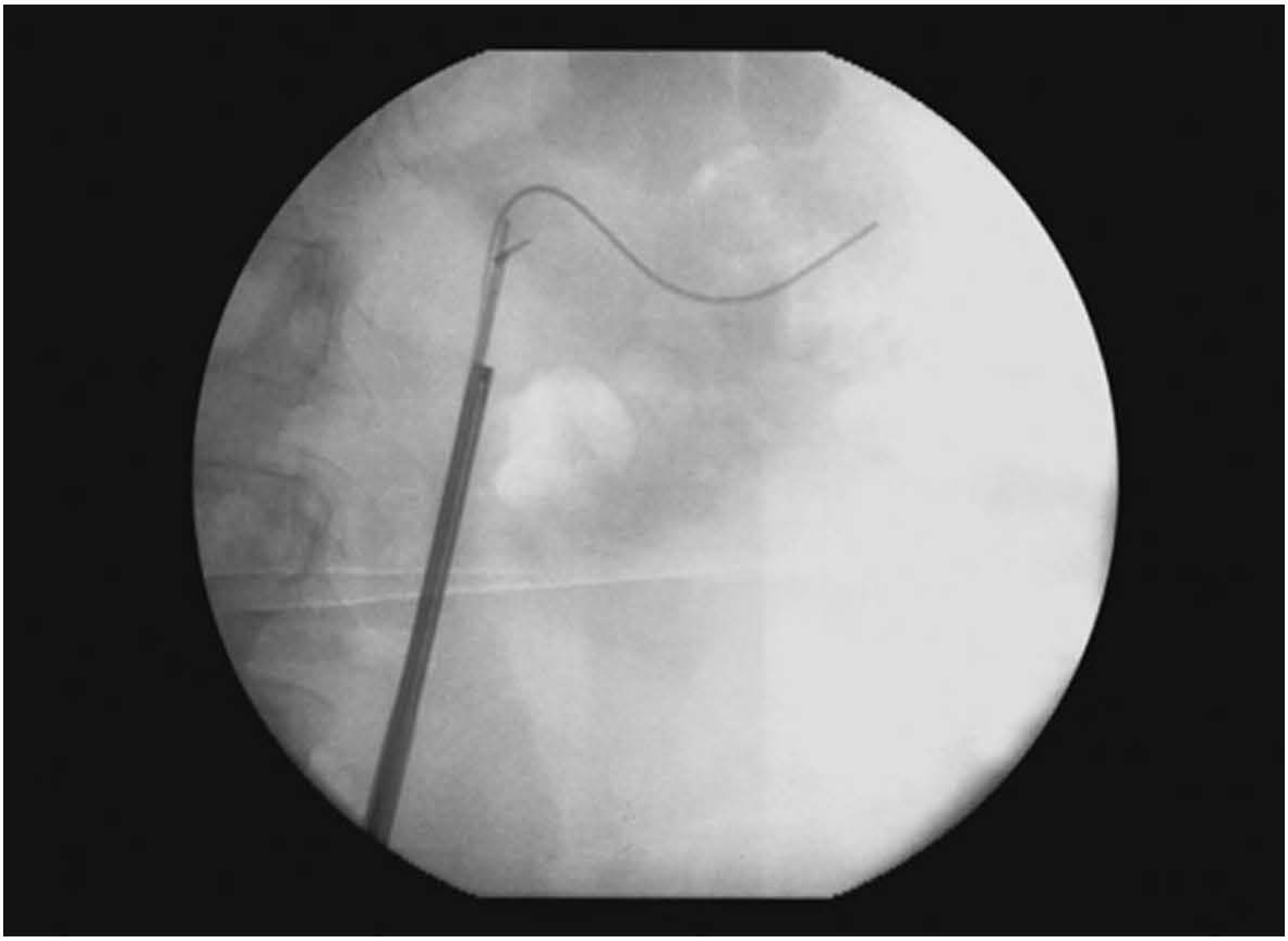


Figure 10.17 **Positioning the cold-blade knife during retrograde endopyelotomy.**

This is sharp on both edges, which makes possible not only the incision by opening the instrument and using the cutting edge from the external part of the upper distal arm (Fig. 10.18), but also cutting through shearing maneuvers (Fig. 10.19).

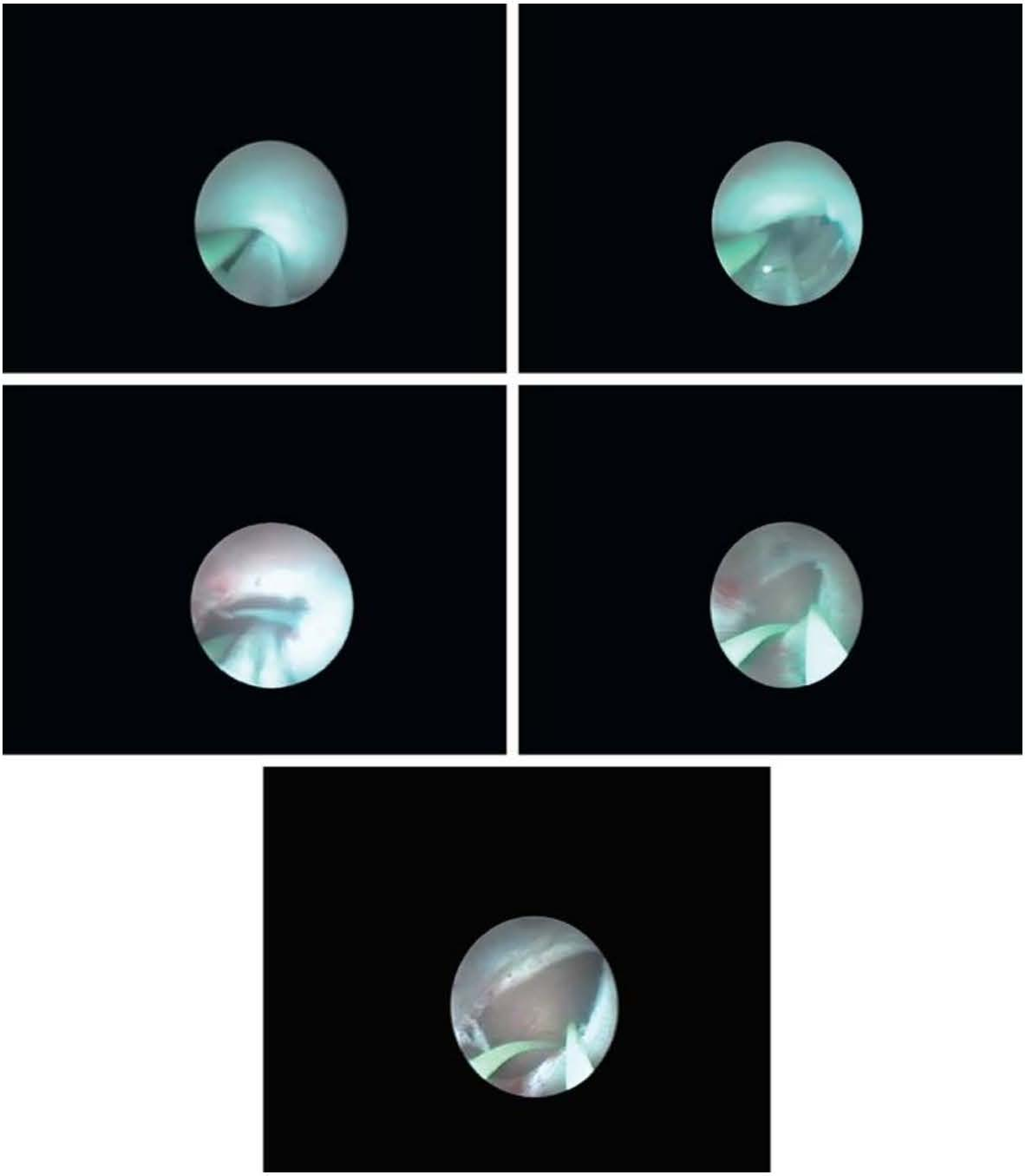


Figure 10.18 **Cold-knife endopyelotomy of a UPJ stenosis.**

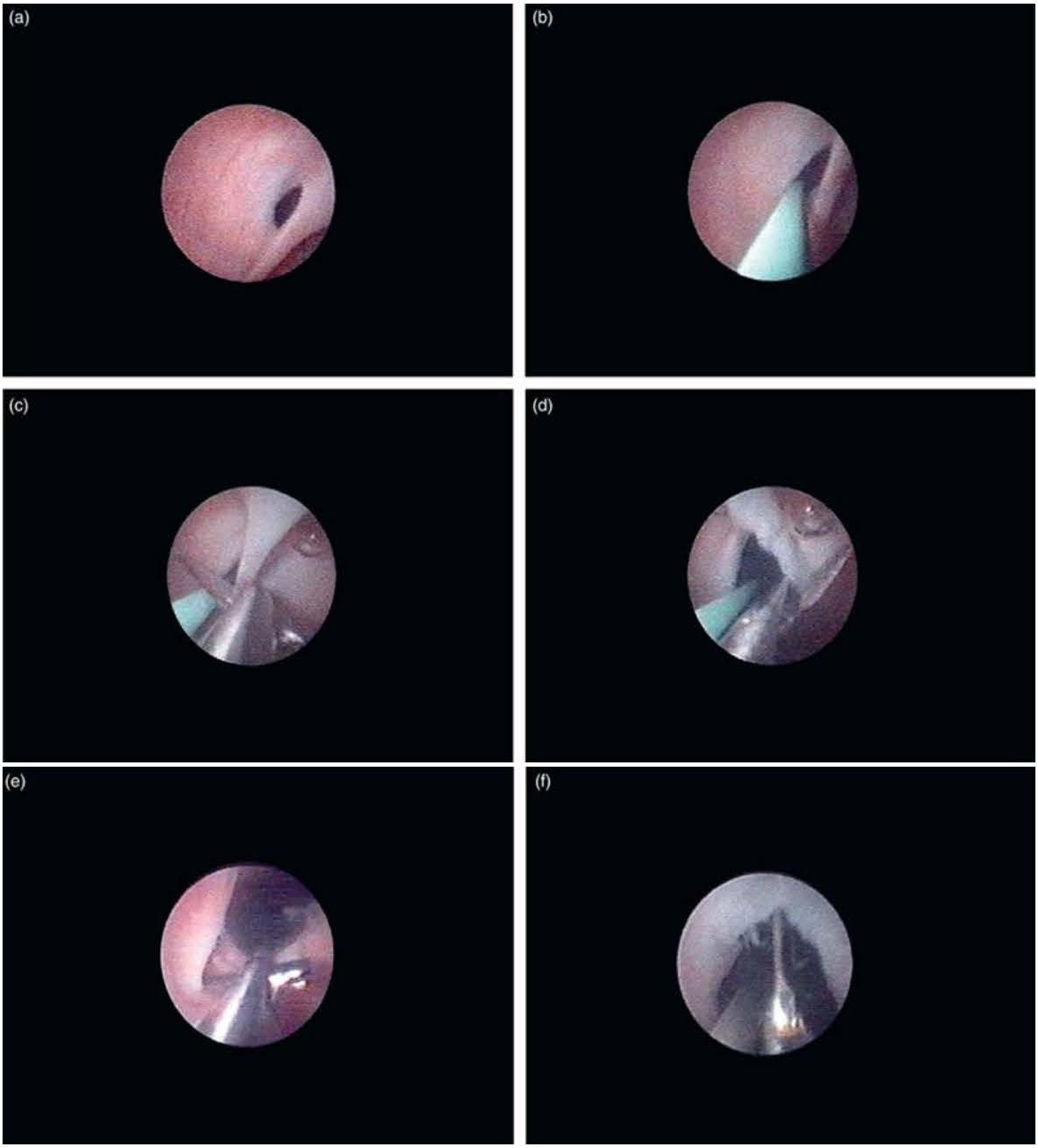


Figure 10.19 **Cold-knife endopyelotomy of a valvular type UPJ stenosis (a, b): cutting the tissue through shearing motions (c, d) followed by widening the junction through progressive incisions in a classic manner (e, f).**

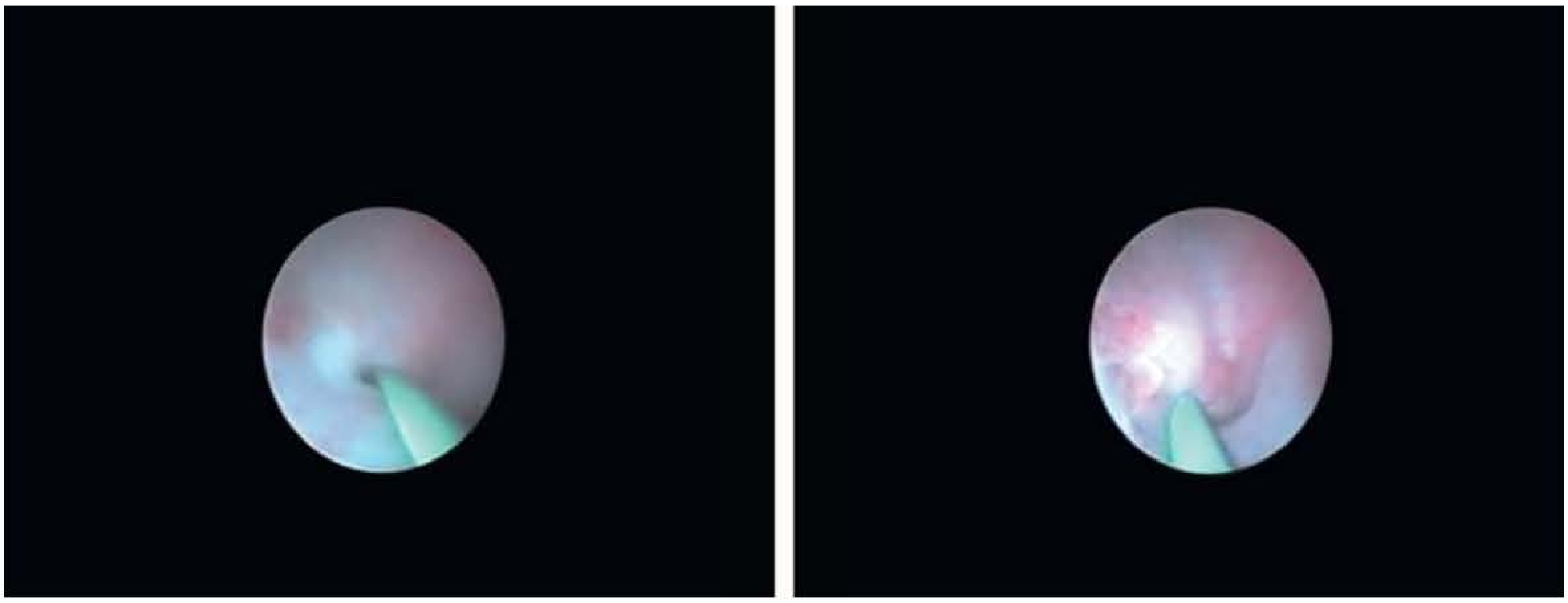
Cold incision can be difficult to perform in case of secondary UPJ stenosis, especially because of the area of fibrosis present at this level. The use of the endopyelotomy knife allows for an accurate incision of the junction (Geavlete et al., 2003a, b). However, the use of the cold knife implies an increased risk of bleeding compared to laser fiber incision.

10.3.4.2. Laser Endopyelotomy

Ho:YAG or Nd:YAG lasers can be used for the incision of stenosed UPJ. It is recommended to use 365 µm fibers on the semirigid ureteroscope, respectively 200 µm fibers on the flexible ureteroscope. Ho:YAG laser incision is preferred because of its increased safety profile, which is due to a reduced tissue penetrability (0.5–1 mm compared to 5–6 mm for the Nd:YAG laser). The use of the Ho:YAG laser also has the advantage of fragmenting existing secondary kidney stones. When using the flexible ureteroscope and the laser, pyelocaliceal stones can be processed during the same procedure.

The laser fiber will be positioned at the proximal end of the area of stenosis or even inside the renal pelvis. The settings of the Ho:YAG laser for incision will be 1.2 J and 10–15 Hz (Seveso et al., 2005). Improper handling of the fiber, triggering it inside the ureteroscope, may cause the destruction of the working instrument, thus compromising the intervention. Small vessels can be coagulated with the laser fiber in a noncontact manner.

Despite the disadvantages of an increased tissue penetrability, the Nd:YAG laser (Fig. 10.20) has the advantage of excellent hemostasis properties.



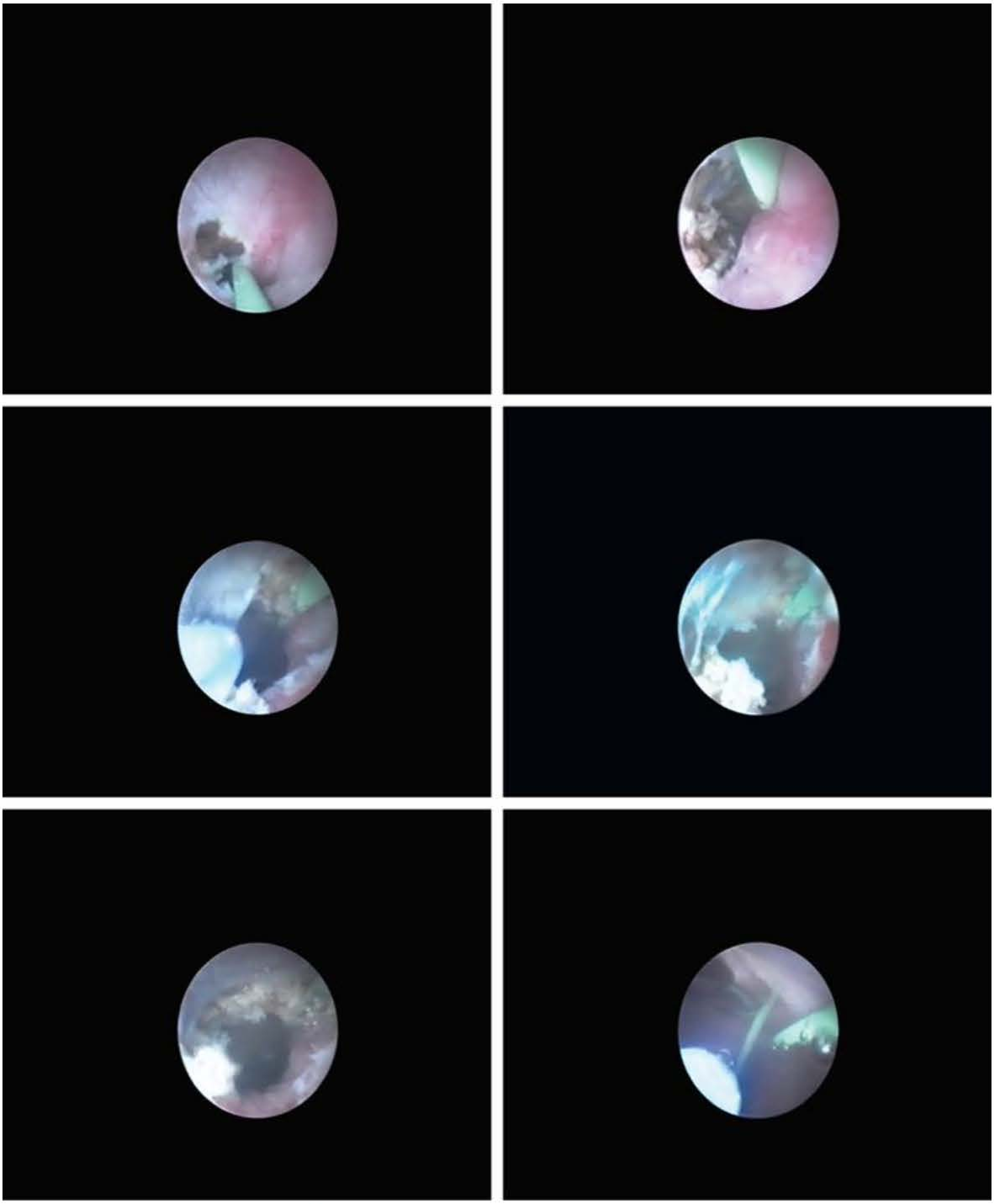


Figure 10.20 **Nd:YAG laser endopyelotomy.**

10.3.4.3. Endopyelotomy With Electrocautery

The incision of the UPJ with electrocautery is achieved by using small electrodes or a Collins loop for the ureteroresectoscope. The use of electrodes makes the incision similar to the one performed with the laser fiber, but with a much more pronounced thermal effect.

In order to prevent possible complications caused by the use of electrical current, it is recommended to isolate the safety metallic guidewire from the ureter and junction. This is done by sliding a ureteral catheter with a permeable end on the guidewire, which also allows for the decompression of the pyelocaliceal system when necessary.

Due to the increased diameter of the ureteroresectoscope, retrograde incision with the Collins loop is more difficult to perform and less frequently used. In addition, the dimensions of the endoscope increase the risk of ureteral wall ischemia.

Due to the partial obstruction of the endoscopic field by the loop, some authors recommend placing it after the ureteroresectoscope has been ascended up to the level of the junction.

10.3.4.4. Acucise Endopyelotomy

The Acucise device consists of a 6–10 F ureteral catheter that presents in its distal part a balloon on which a 150 µm/3 cm filiform electrode is applied.

After passing the stenosis with a metallic guidewire, the Acucise catheter is advanced on it. When the guidewire cannot be ascended to the pyelocaliceal level, it should be placed with the help of the ureteroscope under direct visual control. When the endopyelotomy catheter cannot pass through the stenosis, it is recommended to place a JJ catheter for a period of 2 weeks, resuming the procedure after the passive dilation of the ureter and the junctional zone.

The balloon is positioned under fluoroscopic control, using the two radiopaque markers at its ends as landmarks. In order to visualize the positioning of the endopyelotomy device, injection of contrast agent into the renal pelvis is recommended, and the area of stenosis should be found between the two indicators.

In order to minimize the risk of bleeding, it is absolutely necessary to correctly objectify the incision wire positioned laterally. The fluoroscopic appearance in which the working guidewire crosses the incision wire means a flawed positioning due to the coiling of the latter. In these circumstances, the application of the cutting current will almost inevitably lead to vascular lesions.

Two guidewires are never used in the case of endopyelotomy with the Acucise catheter. After correctly positioning and inflating the balloon with contrast agent diluted with standard saline, incision of the junction is done by applying a cutting current of 75–100 W for 3–5 s. Some authors recommend keeping the balloon inflated for 5–10 min in order to achieve hemostasis by compression (Delvecchio and Preminger, 2000).

Pielography performed after the incision and balloon deflation allows the result to be evaluated immediately through the leakage of the contrast agent at the level of the junction.

If this phenomenon is not visible, it is recommended to repeat the incision during the same procedure (Delvecchio and Preminger, 2000).

10.3.5. Postoperative Stenting

After withdrawing the ureteroscope, a 7/14 F pyelostent will be ascended on the safety guidewire maintained in position (Fig. 10.21), under cystoscopic and fluoroscopic control. The segment with the increased diameter will be positioned in the area where the incision was made (Fig. 10.22).

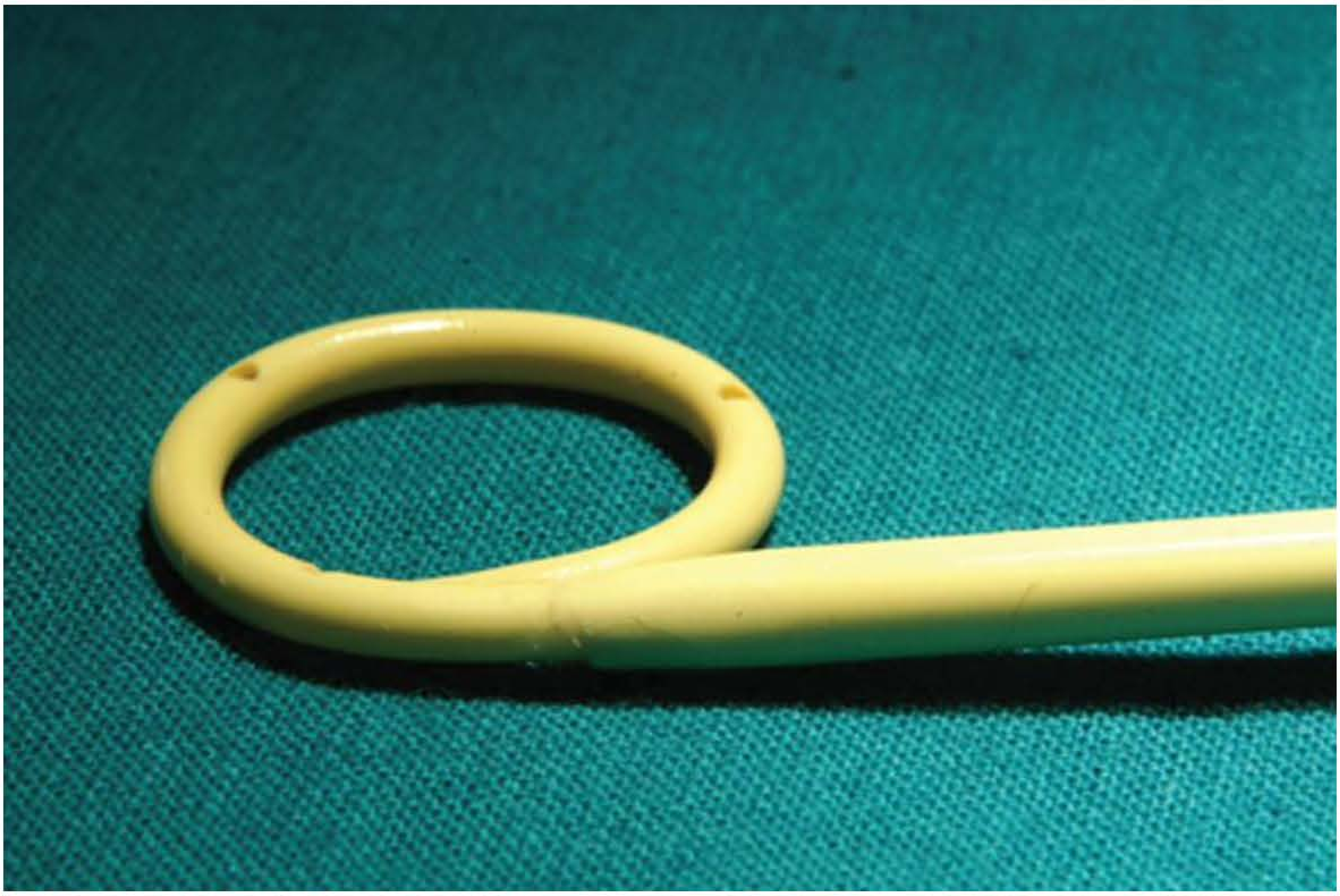


Figure 10.21 Detail of the upper part of a pyelostent.

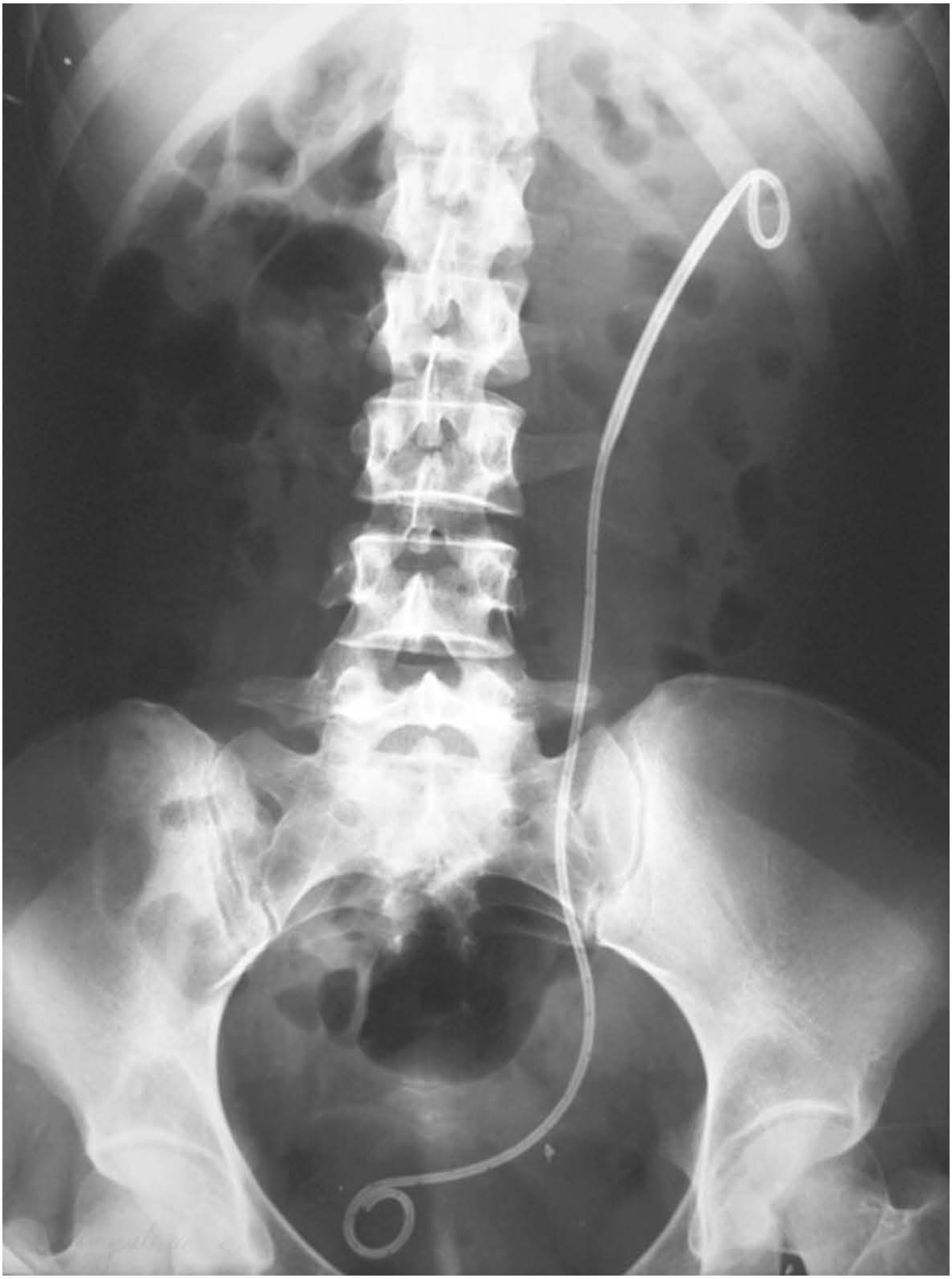


Figure 10.22 **Correctly positioned pyelostent.**

Currently, there are a number of controversies regarding the dimensions of the stents. The main issues regarding the use of pyelostents are related to a potential risk of ischemia and eventually to the difficulties in placing them. Also, some recent studies have suggested that placing a 7 or 8 F JJ stent leads to similar results with those obtained with the 7/14 F endopyelotomy stent (Soria et al., 2005).

However, prospective randomized trials are still necessary in order to determine the optimal dimensions of postendopyelotomy stents.

To prevent vesicoureterorenal reflux, it is recommended to maintain the vesicoureteral catheter for 48 h.

Endopyelotomy is based on the principle of intubated ureterotomy described by Davis, according to which the incision should be made through the entire thickness of the stenotic area, the healing of the ureteral wall taking place in the conditions of prolonged stenting, with a tutoring role.

Studies have been conducted on porcine models in order to reevaluate Davis' original theory on ureteral healing after endopyelotomy. They suggested that the healing of the wound from the area of incision is rather the result of the recruitment of myofibroblasts than that of smooth muscle tissue regeneration. Therefore, wound healing is associated with contraction, a reason for which a larger stent may serve as a tutor rather than as a scaffold for healing (Anidjar et al., 1997).

Histological evaluations have shown that regeneration of the muscularis is complete after 6 weeks of stenting (Hanna et al., 1976). For this reason, most authors recommend maintaining the pyelostent for an average period of 6 weeks.

However, some authors report similar success rates after shorter periods, a possible explanation being that prolonged stenting may initiate an inflammatory response and, consecutively, late fibrosis (Soria et al., 2005).

10.4. Results

The results of retrograde endopyelotomy are still the subject of some controversies. In the last decade this method has aroused particular interest, proof being the large number of articles published in the literature and the papers discussed in all the important international congresses (Table 10.3).

Table 10.3

Results of Retrograde Ureteroscopic Endopyelotomy

Authors	No. of patients*	Incision type	Follow-up (months)	Success rate (%)*	Type of UPJ stenosis
Thomas et al. (1996)	39	Electric	16 (7–37)	90	–
Biyani et al. (1997)	8	Ho:YAG	12.4 (3–24)	87.5	Primary and secondary
Tawfiek et al. (1998)	32 (31/1)	Electric/Ho:YAG	10	87.5	Primary and secondary
Renner et al. (1998)	34	Ho:YAG	18	85	Primary and secondary
Devevey et al. (1999)	13	Cold knife	11.9	84.6	Primary and secondary
Gerber and Kim (2000)	22	Electric/Ho:YAG	20.5	82	–
Giddens and Grasso (2000)	23	Ho:YAG	10 (3–35)	83	Primary and secondary
Geavlete et al. (2001a)	17	Cold knife	12	82.3	Primary and secondary
Hibi et al. (2002)	5	Ho:YAG	12.8 (4–23)	80	–
Parkin et al. (2003)	26	–	19	71	–
Matin et al. (2003)	46	Ho:YAG	23.2 (5–43)	73.1	Primary and secondary
Di Grazia and Nicolosi (2005)	6	Ho:YAG	–	66.6	Secondary
Seveso et al. (2005)	16	Ho:YAG	18 (6–41)	81.3	Primary and secondary
Shilo et al. (2005)	52	Ho:YAG	–	93	–
El-Nahas et al. (2006)	20	Ho:YAG	29.9 (6–48)	85	Primary and secondary
Minervini et al. (2006)	48 (18/30)	Electric/Ho:YAG	24	70.8 (53/80)	–
Ponsky and Streem (2006)	37	Ho:YAG	75.6 (39–133)	77.8	Primary and secondary
Malizia et al. (2006)	17	Ho:YAG	26 (9–52)	82.4	Primary and secondary
El-Azayem et al. (2006)	37	Ho:YAG	–	64.9	Primary and secondary
Doo et al.	75	Cold knife/Ho:YAG/electric	37.3 (3–98)	67.5	–

(2007)					
Geavlete et al. (2007)	30	Ho:YAG	31 (18–52)	83.3	Secondary
Braga et al. (2007)	10	Ho:YAG	47 (15–132)	60	Secondary
Wu et al. (2007)	21	Ho:YAG	13.8 (6.1–15.6)	81	Primary and secondary
Park et al. (2007)	20	–	47.2 (6.2–138.8)	70	Secondary

[*] For the groups in which different types of incision were used, the results according to the incision type are shown in brackets, if there were significant differences.

However, the series reported included a limited number of patients that did not allow statistically significant, unanimously accepted results to be obtained. For this reason, the development of precise indications supported by extensive studies and meta-analyses could solve the current controversies and, through an appropriate selection of cases, could improve the results of retrograde endopyelotomy.

The success rate reported in the literature for this method varies between 53% and 90%, being influenced by the follow-up period, but also by the way of defining success. The evaluation of the results of endopyelotomy became more accurate with the widespread use of certain methods such as renal scintigraphy, which, compared to IVU, ultrasonography, and symptom assessment, provides more accurate data that also allow for much more subtle interpretations (Vaze, 2002). Thus, a number of studies separately report a result based on subjective criteria and an objective success rate (Umekawa et al., 1999; Lam et al., 2003; El-Nahas et al., 2006). The calculation of the first parameter uses anamnesis and questionnaires, the intervention being considered a success if the intensity of symptoms improves by at least 50% (Hoenig et al., 1998). The evaluation of objective results includes the morphofunctional exploration of the upper urinary tract by IVU, renal scintigraphy, and/or the Whitaker test. Significant differences can appear between these two definitions of success of the intervention. Thus, Umekawa et al. (1999) recorded a success rate calculated on subjective criteria of 92% compared to an objective one of only 62%.

Studies have also identified other factors that could significantly influence the results of the procedure:

- association of polar vessels
- degree of hydronephrosis
- preoperative renal function
- type of incision used
- type of stenosis

Parkin and coworkers evaluated the success rates of retrograde endopyelotomy associated with endoluminal ultrasonography. Despite establishing the incision site by imaging criteria, the success rate in patients with polar vessels was of only 55% compared to 85% in those without these vascular abnormalities (Parkin et al., 2003). Similarly, a study that assessed the differences of Acucise endopyelotomy in patients with or without polar vessels showed success rates of 45% compared to 81% (Lechevallier et al., 1999).

In another study, Van Cangh et al. (1994) analyzed the influence of the presence of polar vessels and of high-grade hydronephrosis on the results of endopyelotomy, reporting a success rate of only 39% when both are present versus 95% in patients without these pathological changes.

Lam studied the impact of the degree of hydronephrosis on the results of retrograde endopyelotomy. The success of this procedure decreased from 90% to 100% in patients with slight or moderate dilation of the pyelocaliceal system to 20–60% for those with massive or severe hydronephrosis. However, the antegrade approach seems to have better results than the retrograde approach in patients with significant dilation of the pyelocaliceal system.

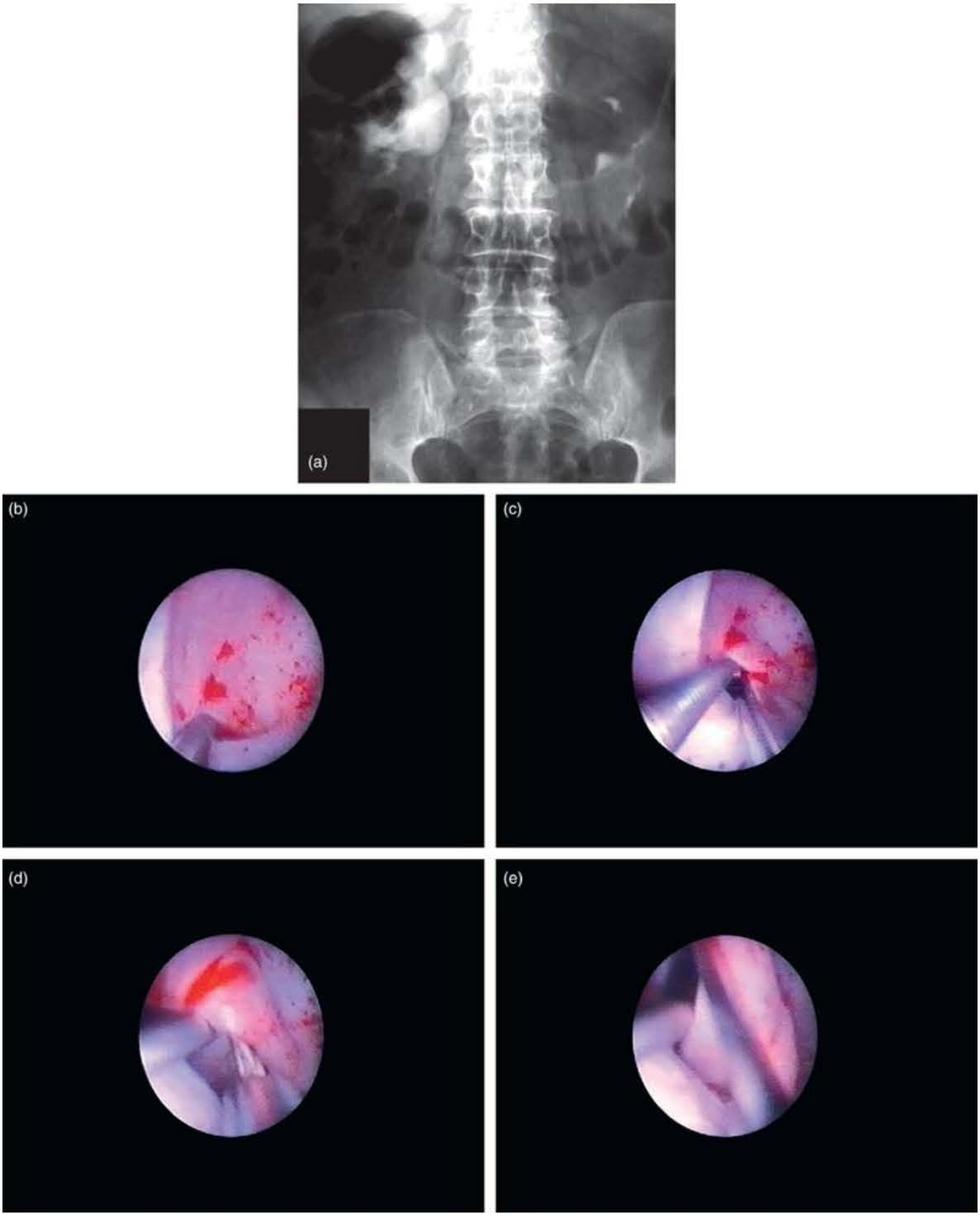
The same study evaluated the influence of preoperative renal function on the results of the retrograde intervention. Thus, success rates of 42.9, 60, and 91.7% were recorded for patients with ipsilateral renal function below 25%, between 25% and 40%, and higher than 40%, respectively.

Antegrade approach determined better results in these cases also, but without statistically significant differences (Lam et al., 2003).

Similarly, Kapoor and coworkers assessed the results of endopyelotomy according to the glomerular filtration rate. For values below 15 mL/min, the success rate of the intervention was only 62% compared to 90% for a glomerular filtration rate of 15–25 mL/min (Kapoor et al., 2001).

The instruments used for incision also seem to influence the long-term results of endopyelotomy.

The initial studies regarding cold-knife endopyelotomy (Fig. 10.23) showed promising results (Devevey et al., 1999; Geavlete et al., 2001a). Thus, assessing a group of 13 patients who underwent cold-knife endopyelotomy, Devevey et al. (1999) reported a success rate of 86.4%, but the follow-up period was relatively short, of only 11.9 months.



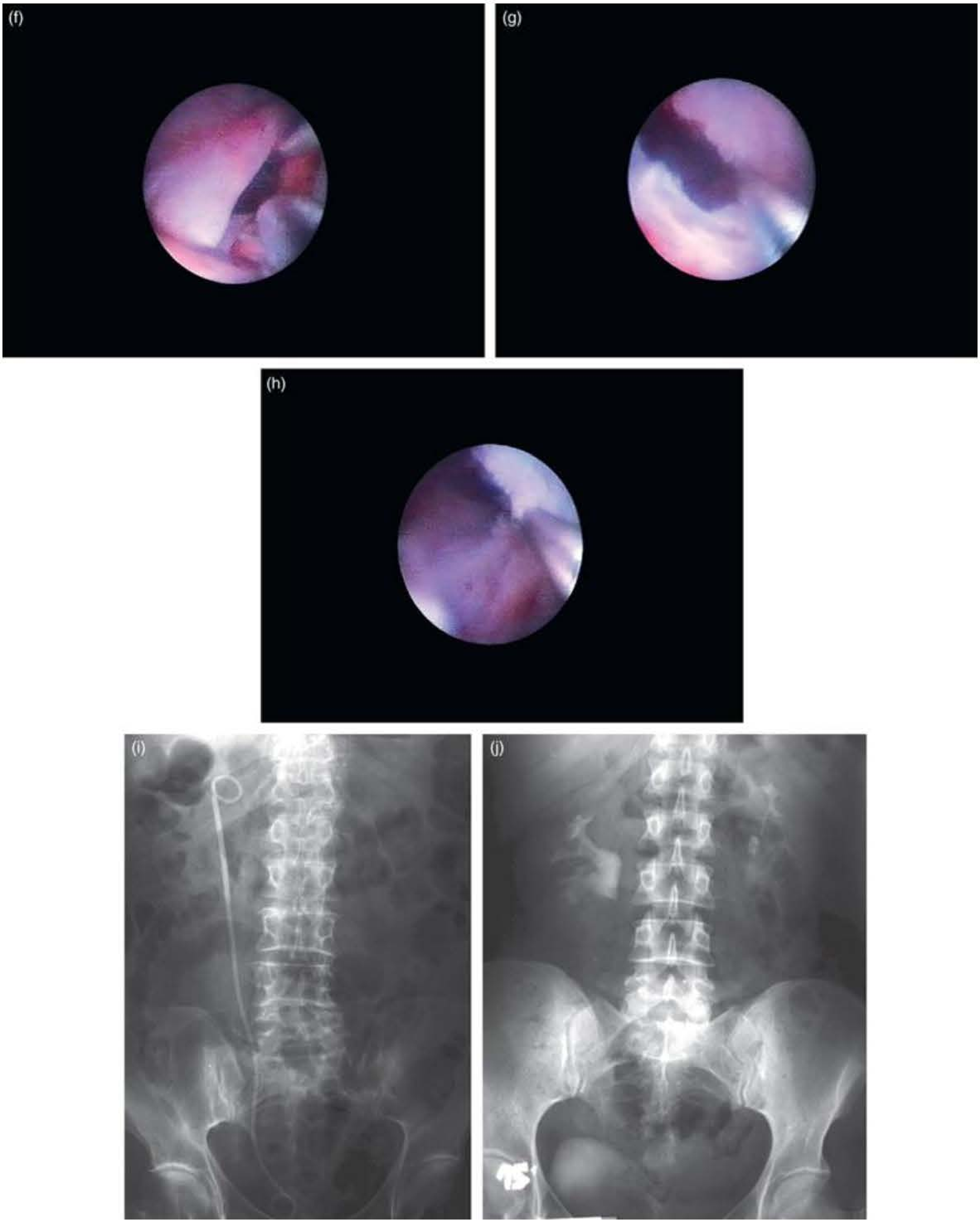
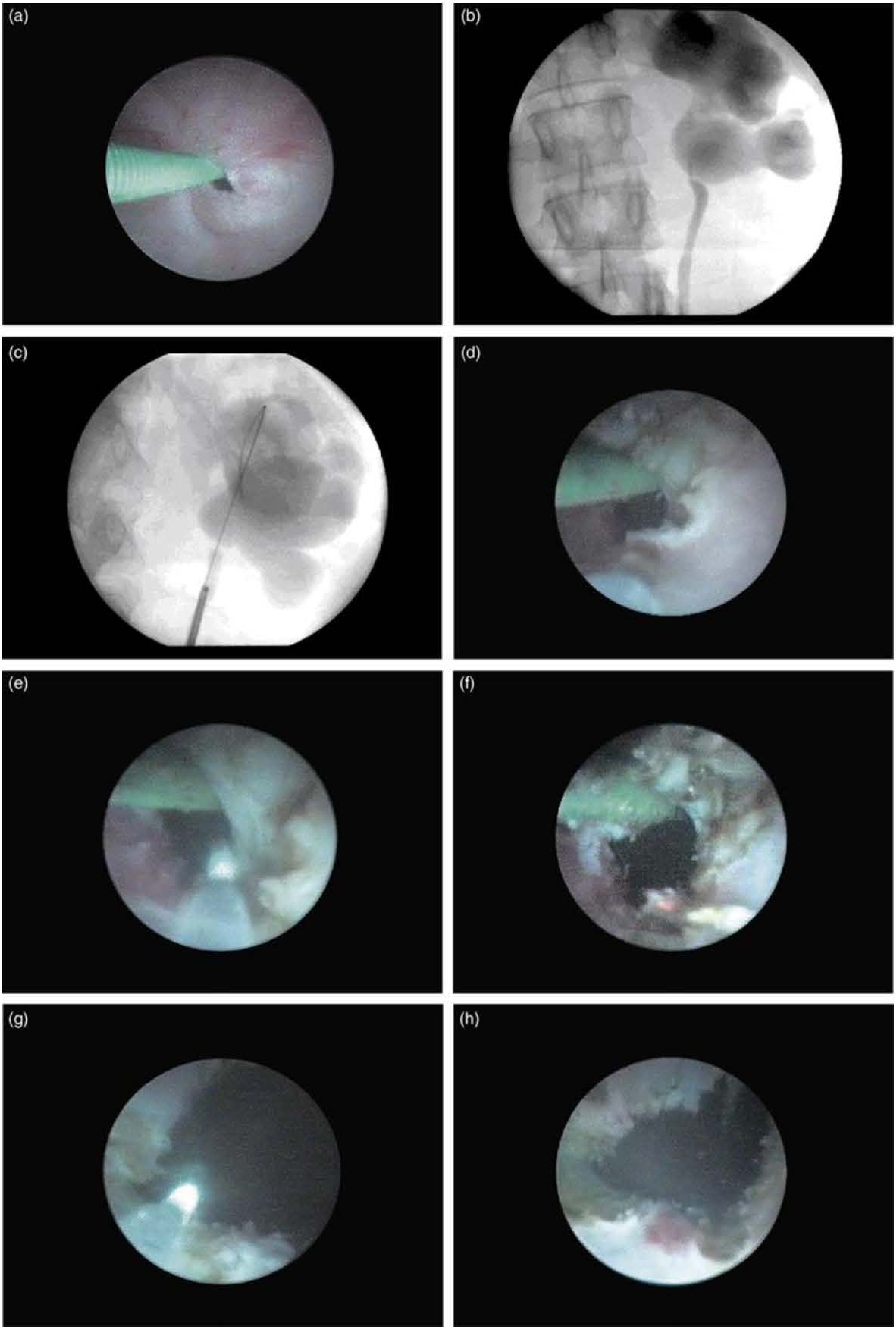


Figure 10.23 **Cold-knife endopyelotomy.**

Urographic (a) and endoscopic (b) aspect of the right UPJ stenosis, cold-knife incision (c–g), wide aspect of the junction (h), correctly positioned pyelostent (i), and urographic control at 3 months (j).

However, reevaluations have shown an increase in the long-term recurrence rate.

Laser incision (Fig. 10.24) is being used more and more frequently in the present, especially the Ho:YAG (Fig. 10.25), due to the higher success rates.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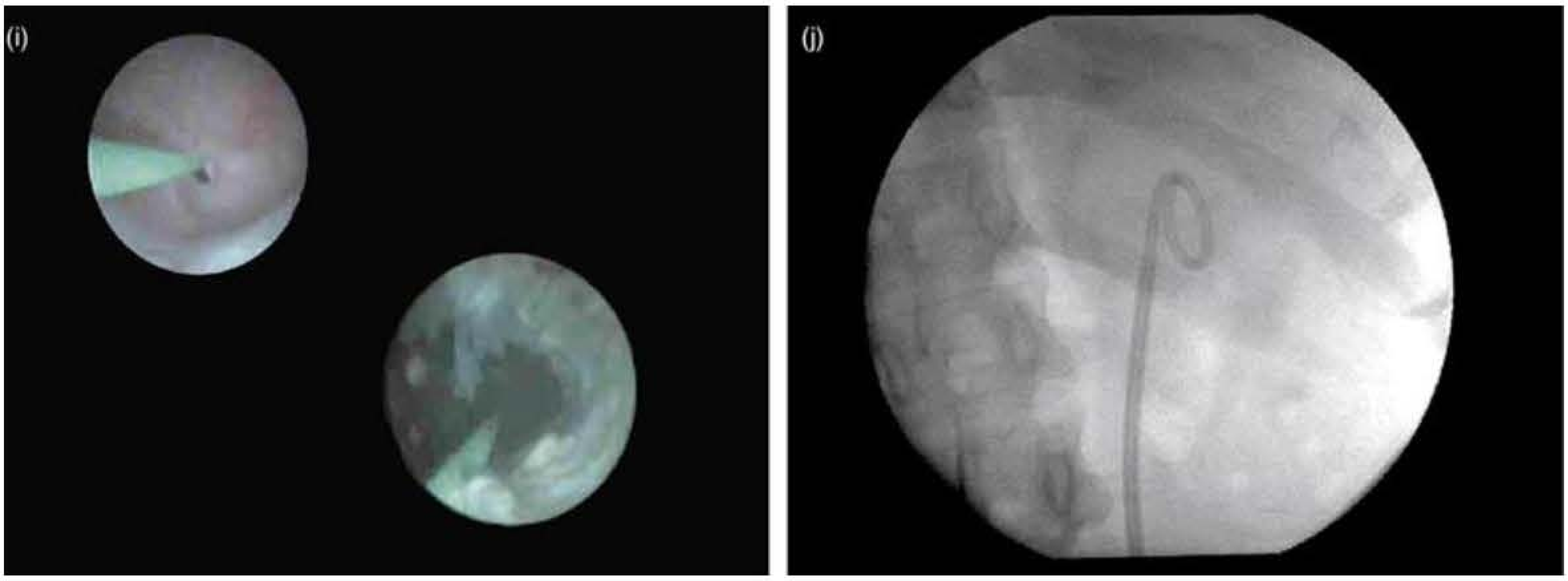
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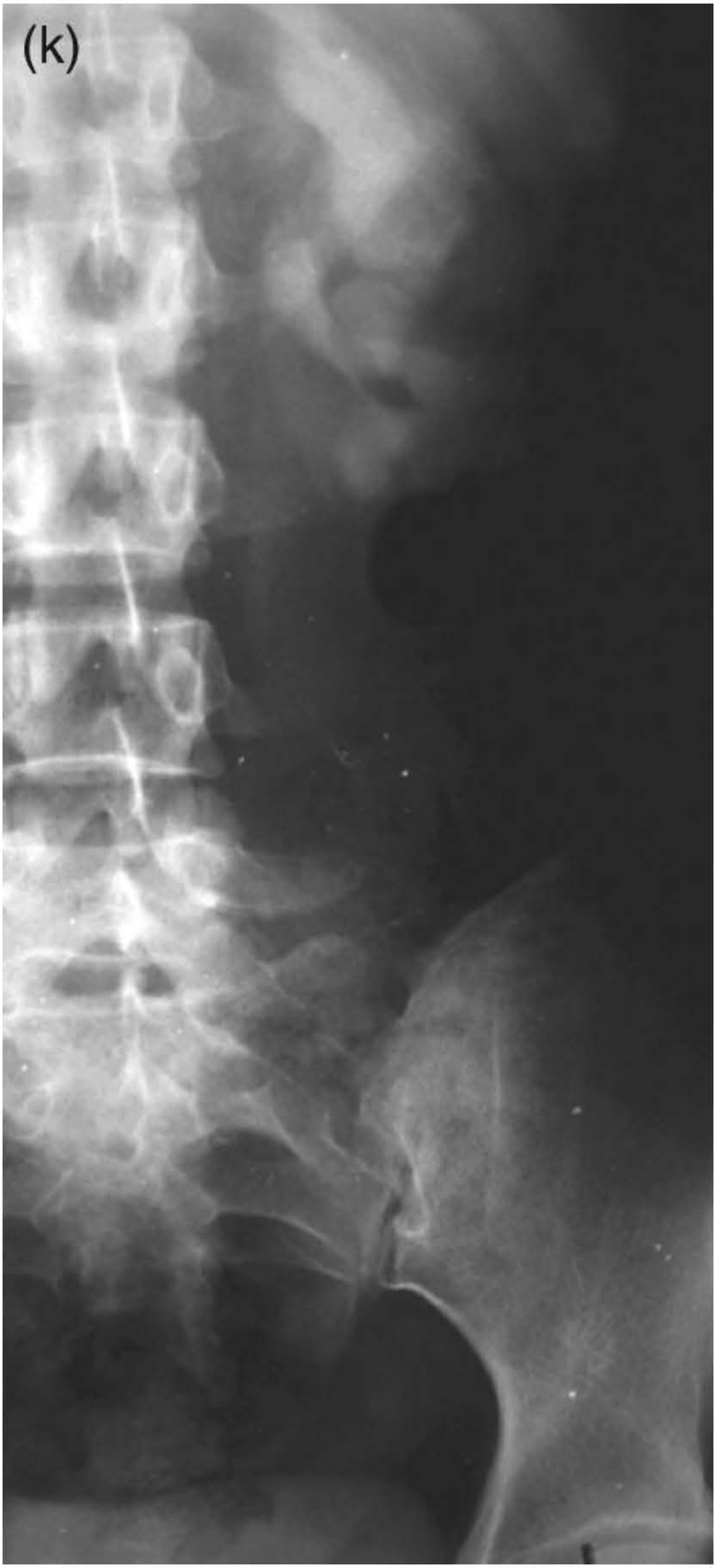


Figure 10.24 Retrograde Nd:YAG laser endopyelotomy.

Endoscopic (a) and fluoroscopic (b, c) aspect of the left UPJ secondary stenosis, laser incision (d–h), comparative pre- and postoperative aspect of the junction (i), correctly positioned pyelostent (j), and control urography at 3 months (k).

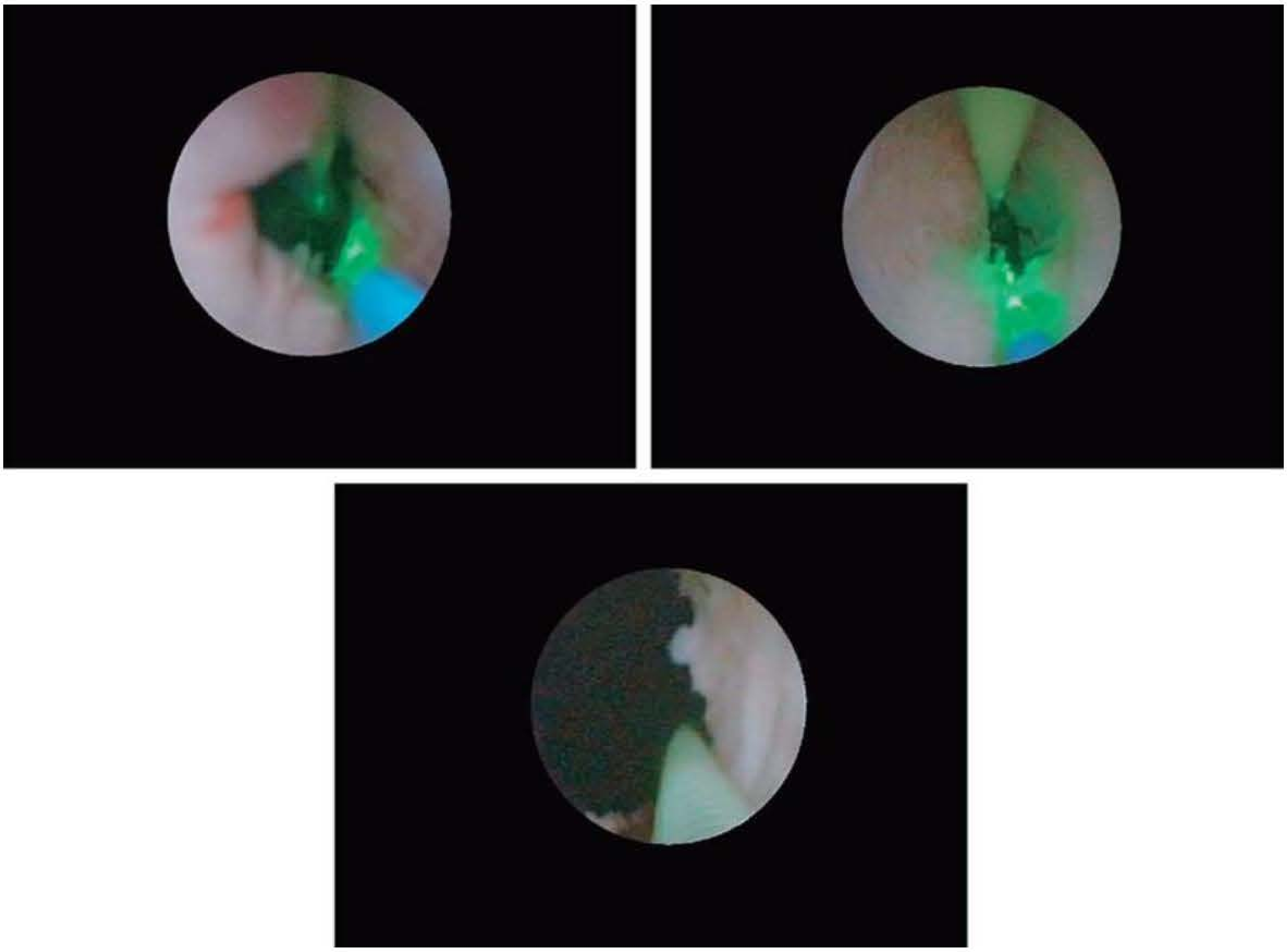
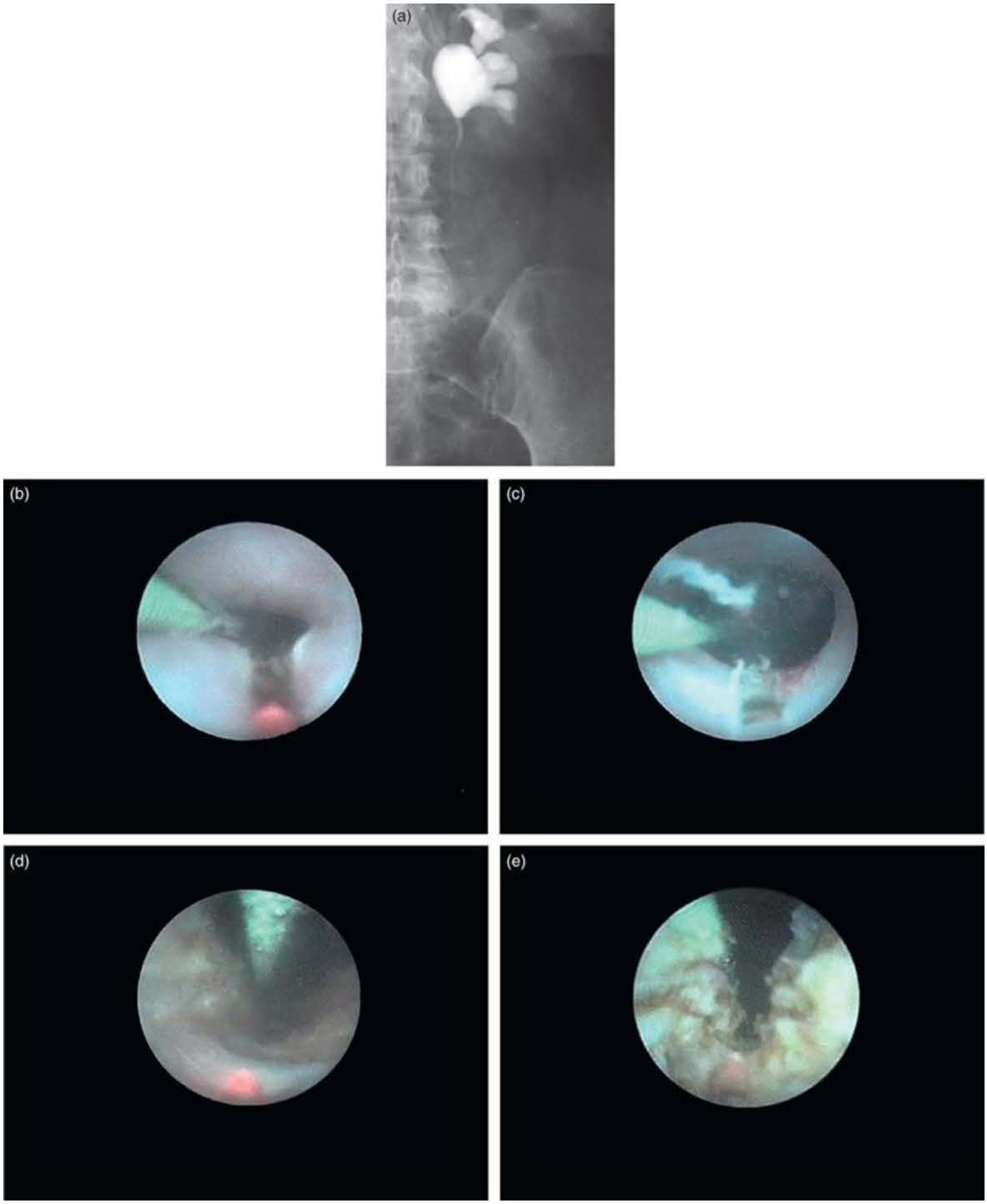


Figure 10.25 **Retrograde Ho:YAG laser endopyelotomy.**

Similarly, Minervini et al. (2006) compared the success rates of laser endopyelotomy and endopyelotomy with electrocautery, achieving success rates of 80 and 53%, respectively.

The results of endopyelotomy also seem to be influenced by the type of stenosis: primary (Fig. 10.26) or secondary (Fig. 10.27).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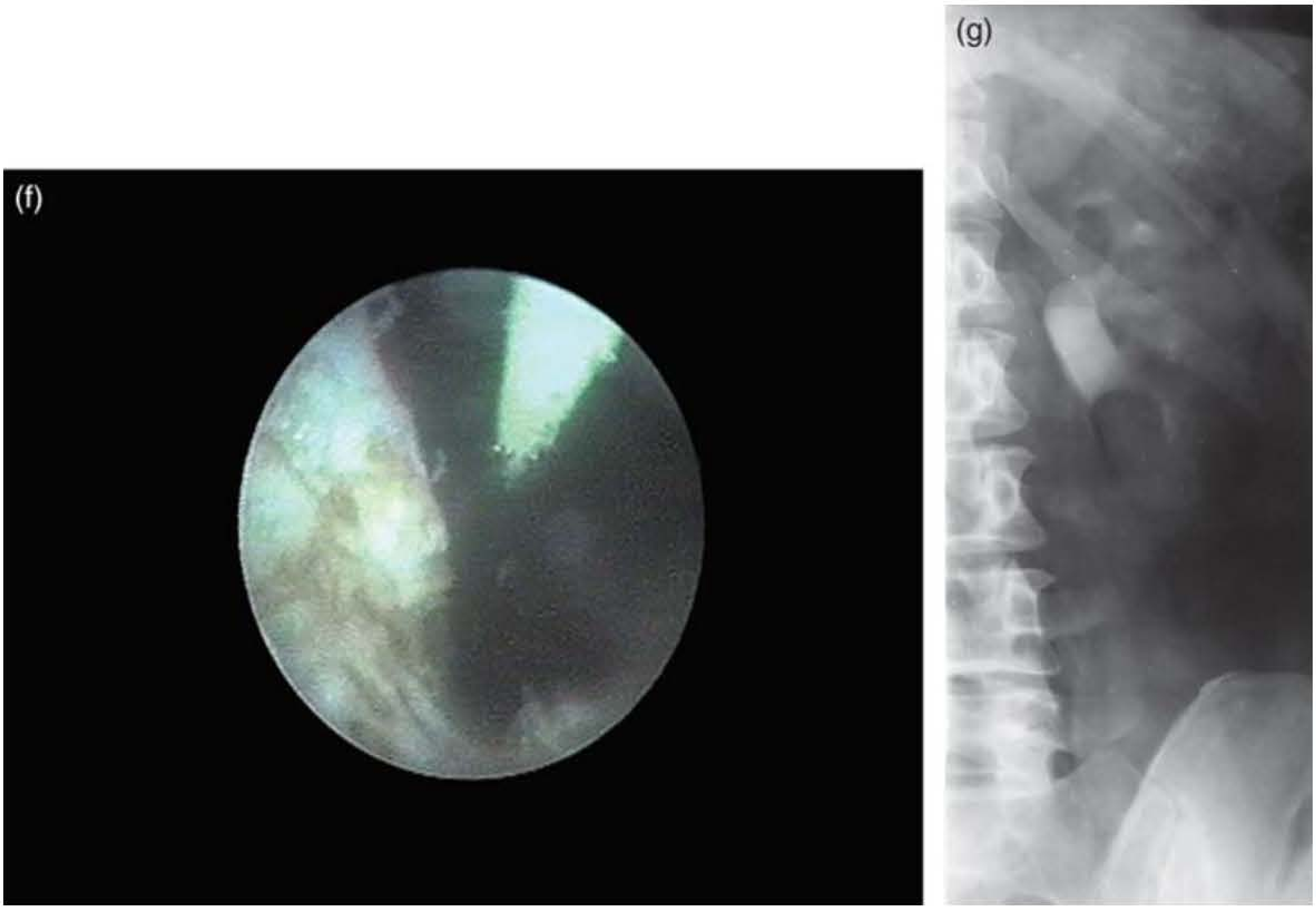
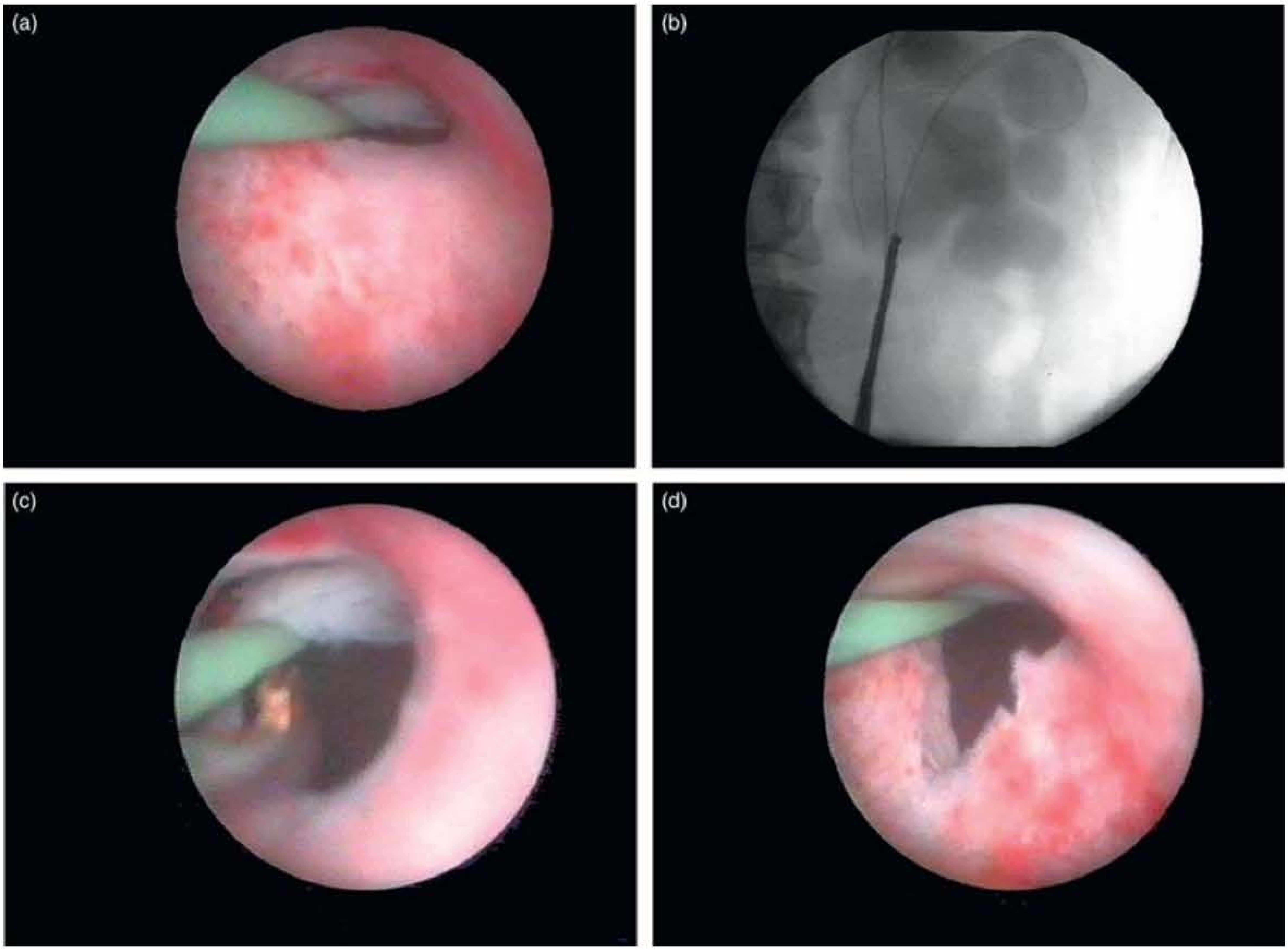


Figure 10.26 Retrograde laser endopyelotomy of a primary UPJ stenosis (a): progressive laser incision of the stenotic area (b–e), wide aspect of the junction at the end of the intervention (f), and urographic control at 6 months (g).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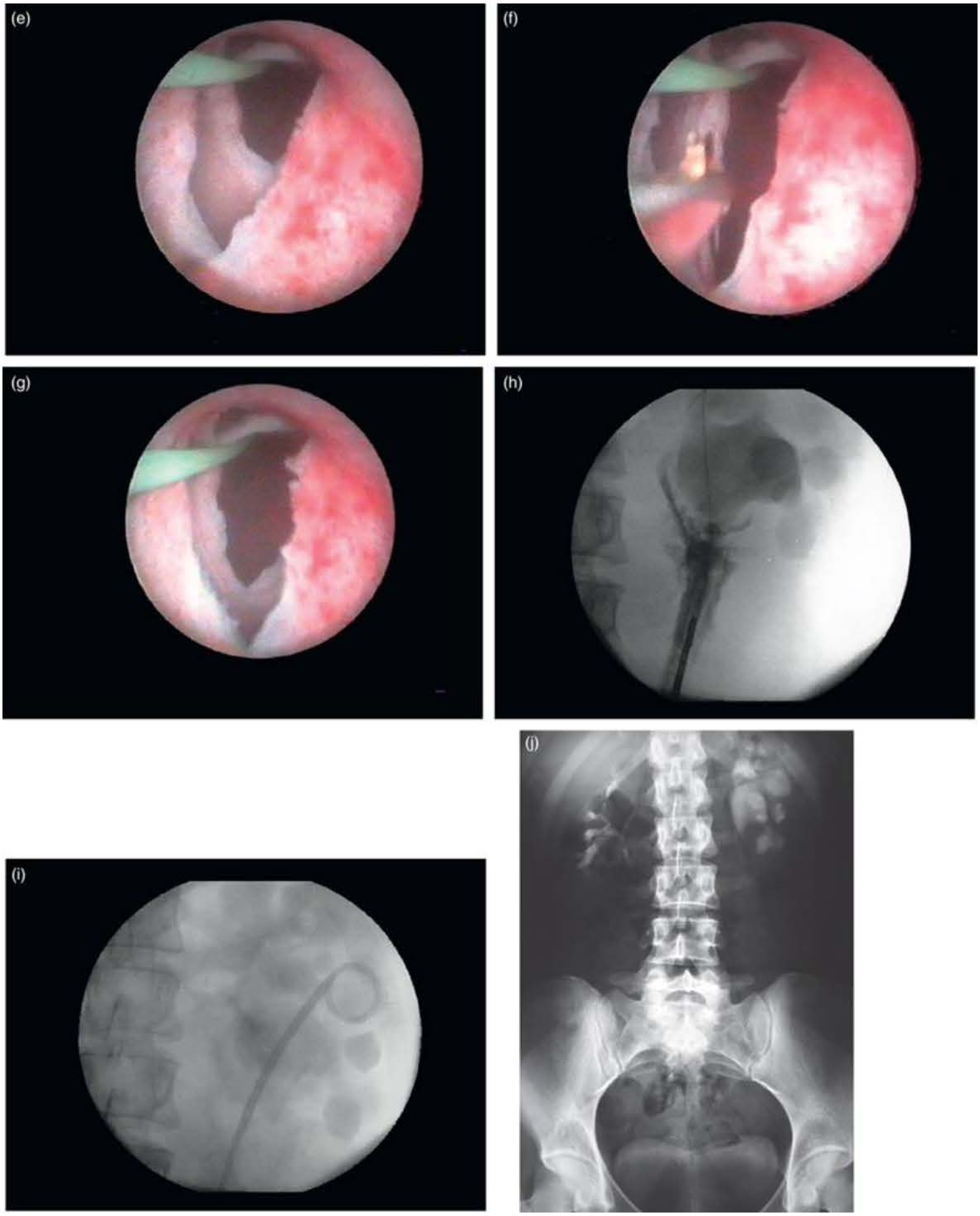


Figure 10.27 **Retrograde cold-knife endopyelotomy.**
Endoscopic aspect of a left UPJ secondary stenosis (a), with third degree suprajacent hydronephrosis (b), progressive cold-knife incisions (c–g), contrast agent leakage on the retrograde pyelography (h), correctly positioned pyelostent (i), urographic control at 3 months (j).

Thus, Di Grazia reports a success rate of endopyelotomy for UPJ stenosis recurring after pyeloplasty of only 66.6%. Similarly, Matin et al. (2003) describe lower success rates of the procedure for secondary stenoses than for primary ones (50% vs. 68%). Most studies that included only cases with endopyelotomy for secondary stenoses reported success rates ranging between 60% and 70%. In contrast, in studies in which the patient groups also included patients with primary stenosis, the procedure's efficiency varied between 81% and 87.5% in most cases.

However, the importance of these prognostic factors is still a subject of controversy. In a recent study published by Doo, the long-term outcomes of endopyelotomy were assessed. The authors analyzed 85 endopyelotomies (75 retrograde and 10 antegrade) performed in 77 patients, with a mean follow-up period of 37.3 months (reaching 98 months in some cases). According to the Kaplan–Meier curve, the success rates were of 87.8% at 6 months, 76.9% at 12 months, 72.2% at 18 months, 68.7% at 24 months, 64.8% at 36 months, and 61.6% at 60 months. However, unlike the studies previously mentioned, the success of the procedure was not influenced by the etiology of stenosis, the instrument with which the incision was made, impaired preoperative renal function, or the degree of associated hydronephrosis (Doo et al., 2007).

Similarly, assessing the results of retrograde endopyelotomy in a group of 22 patients, Gerber and Kim (2000) did not identify any difference in the success rates according to the dimensions of the pyelostent placed at the end of the intervention, to the etiology of stenosis or to the type of incision.

Compared to the ureteroscopic approach, the major disadvantage of Acucise endopyelotomy consists of the fact that it does not allow for the direct visualization of the junction and for the certainty of a complete and correct incision. In addition, the lack of endoscopic control does not allow for avoiding the polar or aberrant vessels from the junctional level while performing endopyelotomy.

The results of endopyelotomy with the Acucise device range between 32% and 92.3% (Table 10.4).

Table 10.4

Results of Acucise Endopyelotomy

Authors	No. of patients	Incision type	Follow-up (months)	Success rate (%)	Type of UPJ stenosis
Nadler et al. (1996)	28	Acucise	32.9 (24–43)	81	Primary and secondary
Faerber et al. (1997)	32	Acucise	14 (3–28)	87.5	Primary and secondary
Shalhav et al. (1998)	8	Acucise	26	70	–
Gill and Liao (1998)	13	Acucise	17.7 (7–33)	61.5	Primary
Willard et al. (1998)	13	Acucise	8.4 (2–21)	92.3	–
Kim et al. (1998)	77	Acucise	–	78	–
Umekawa et al. (1999)	13	Acucise	–	62	Primary and secondary
Lechevallier et al. (1999)	36	Acucise	24 (6–42)	75	Primary
Brito et al. (2002)	27	Acucise	–	85.2	Primary and secondary
Lam et al. (2003)	29	Acucise	37 (5–76)	75.9	–
Sofras et al. (2004)	22	Acucise	3	32	Primary and secondary
El-Nahas et al. (2006)	20	Acucise	29.9 (6–48)	65	Primary and secondary
Ponsky and Streem (2006)	27	Acucise	75.6 (39–133)	74.2	Primary and secondary

Comparing Ho:YAG laser retrograde endopyelotomy with Acucise endopyelotomy, El-Nahas obtained a higher success rate with the first method (85% vs. 65%). However, in a similar study, Ponsky and Streem reported similar results for the two methods of incision (74.2 and 77.8%, respectively), but with the occurrence of major complications in the Acucise group: two patients with bleeding that required blood transfusions and selective embolization (Ponsky and Streem, 2006).

Sofras et al. (2004) reported a low success rate for Acucise endopyelotomy, recommending this method only for patients with UPJ stenosis, with slight hydronephrosis and good renal function. However, in a similar study, Lechevallier reported an overall success rate of 75%, which was not influenced by the degree of obstruction and the type of stenosis (primary or secondary). Multivariate analysis of the results identified a single predictive factor for the intervention's efficiency: the presence or absence of polar vessels, associated with success rates of 45 and 81%, respectively. In the same study, repeating the incision in cases of failure that did not present polar vessels was accompanied by a 75% success rate (Lechevallier et al., 1999).

10.5. Complications

Retrograde endopyelotomy can be encumbered by the occurrence of nonspecific complications attributable to the ureteroscopic approach, as well as by specific incidents and complications caused by the actual stenosis incision.

The rate of complications reported in the literature varies between 0% and 15% (Renner et al., 1998; Giddens and Grasso, 2000; Shilo et al., 2005; El-Nahas et al., 2006).

The nonspecific complications may include traumatic lesions of the ureteral wall (from simple mucosal abrasions to perforations or even complete avulsion), bleeding, fever, pyelonephritis, stenosis, etc. Walz et al. (2003) reported a 28% incidence of septic complications including pyelonephritis in 4% or even sepsis in 2% of cases. In general, infectious complications can be prevented by peri- and postoperative administration of broad-spectrum antibiotics.

In terms of specific complications, the most significant one is represented by bleeding secondary to the incision by damaging aberrant vessels adjacent to the junction. The management of this complication may include measures ranging from surveillance, eventually associated with hemodynamic reequilibration, to selective arterial embolization or, in extreme cases, even open surgery, including nephrectomy (Kim et al., 1998; Bernardo and Smith, 1999; Di Grazia and Nicolosi, 2005).

In case of Acucise endopyelotomy, the strict fluoroscopic control of the maneuver cannot detect the presence of polar vessels or the depth of the incision, the risk of hemorrhagic complications being increased compared to the other variants of retrograde approach. Assessing a group of 50 patients who underwent this intervention, Walz et al. (2003) recorded minor hemorrhagic complications in 14% of cases and major bleeding in 8% of patients, resolved by selective embolization or open surgery.

The methods for identifying polar vessels (preoperative imagistic exploration and intraoperative direct visual assessment of the presence of pulsations at the junctional level) have significantly reduced the incidence of this complication, allowing for a better selection of cases.

In 2006, Hendrikx assessed the role of endoluminal ultrasonography versus spiral CT in determining the presence of polar vessels at the junctional level. Ultrasonography showed a 73% success rate in detecting polar vessels, the selection of patients using this method preventing significant postoperative bleeding (Hendrikx et al., 2006). The severity of perioperative bleeding has also been reduced, which, together with an increased accessibility to selective arterial embolization, has significantly reduced the number of patients who required emergency nephrectomy (Mendez-Torres et al., 2004).

An exceptional complication reported by Schwartz and Stoller (1999) was the injury of the ovarian vein near its confluence with the renal vein, which required vein ligation and nephrectomy. Another intraoperative complication is the migration of the pyelostent at the level of the junctional breach (most often due to a faulty placement), which may be accompanied by serious consequences. Identification of this complication requires immediate and correct repositioning of the pyelostent.

Also, although with a reduced frequency, intraoperative incidents caused by the deterioration of instruments have been reported, sometimes requiring endoscopic maneuvers in order to solve the problem. Thus, sectioning of the safety guidewire, rupture of the Acucise catheter balloon, or sectioning of its filiform electrode have been described (Schwartz and Stoller, 1999; Di Grazia and Nicolosi, 2005).

A relatively frequent postoperative complication is represented by vesicoureterorenal reflux, which can be prevented by maintaining the Foley catheter for 48 h after the intervention. In some cases, the reflux through the pyelostent causes lumbar pains and fever after the extraction of the urethrovesical catheter, phenomena that may require indwelling the catheter again.

In addition to these, complications related to the presence of the pyelostent may also occur: ascending or descending migration (Fig. 10.28), irritative symptoms, etc.

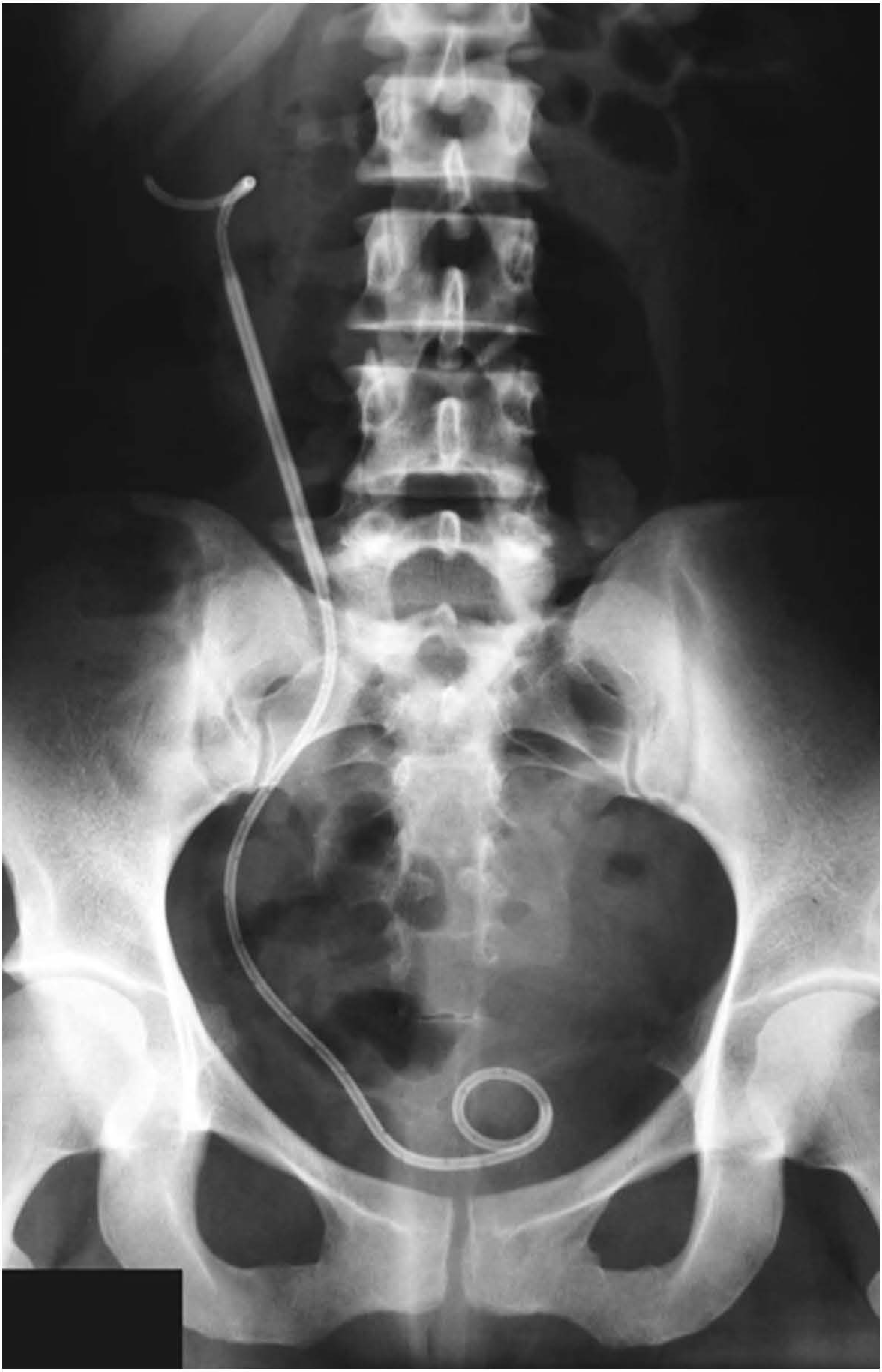


Figure 10.28 **Migrated pyelostent with the increased caliber segment migrated distal to the incision area.**

Ureteral stent migration is resolved endoscopically by repositioning or replacement. Irritative symptoms benefit from antialgic and antispastic therapy.

Other possible complications mentioned in the literature are represented by subcapsular hematoma, retroperitoneal urinoma, or ileus (Faerber et al., 1997; Matin et al., 2003).

10.6. Follow-up

The relatively high rate of recurrence, as well as the differences (sometimes significant) between the subjective and the objective success of the intervention (Umekawa et al., 1999), require careful follow-up of these patients, including investigations that reflect the status of the affected renal unit as accurately as possible (Vaze, 2002).

The investigation protocol can include anamnesis and questionnaires for quantifying pain, ultrasound explorations, renal scintigraphy, IVU, or CT.

Most authors recommend performing the first assessment by IVU and/or renal scintigraphy 4 weeks after the removal of the pyelostent. In the first year after the intervention, these investigations will be repeated every 3–6 months (Fig. 10.29), after which the reevaluation visits will be conducted every 12 months or as needed (Mendez-Torres and Thomas, 2007).

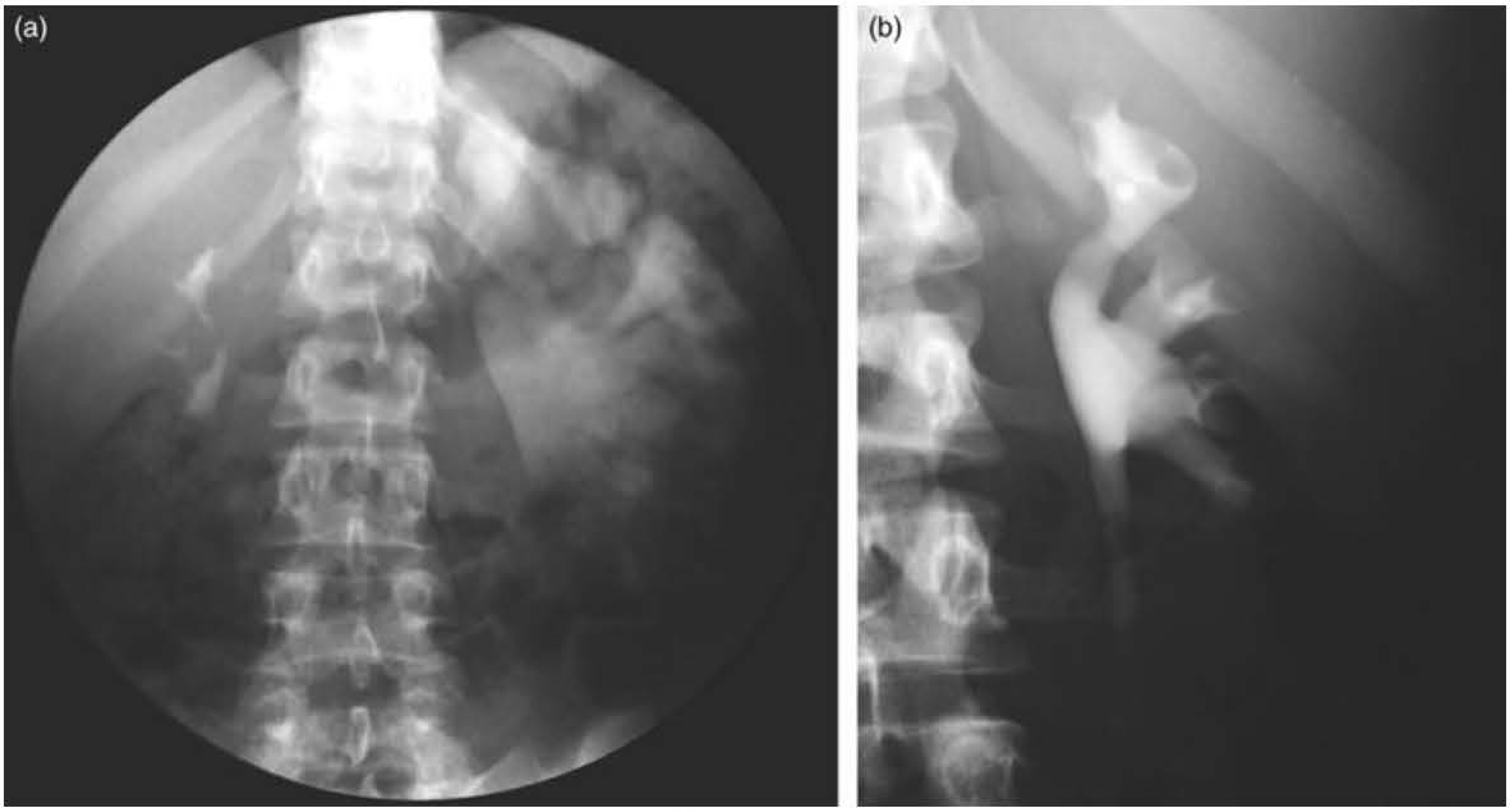


Figure 10.29

Left UPJ stenosis.

(a) Preoperative UIV and (b) 3 months after the intervention.

After the endoscopic intervention, the imagistic methods for assessing morphology ("grayscale" ultrasonography, IVU, CT) may identify a degree of dilation of the pyelocaliceal system (Mendez-Torres and Thomas, 2007). In these cases, renal scintigraphy may reveal persistent obstruction or, on the contrary, its absence, a situation in which hydronephrosis can be considered as residual, without a functional impact. In the attempt to replace this investigation with a less invasive one, some authors have studied the possibility of using Doppler ultrasonography in order to assess the renal resistive index. Although this parameter has proved to be useful in identifying the obstruction, it may be directly or indirectly influenced by a number of factors (sonographer's experience, age of the patient, anesthesia, hemodynamic parameters) (Geavlete et al., 2001a; Soria Gálvez et al., 2007).

There is no consensus in the literature regarding the maximum follow-up period.

In a recent study, Minervini et al. (2006) reported a mean period until the development of recurrences of 10 months for laser endopyelotomy compared to 21 months for electric incision. Doo et al. (2007) consider that although most recurrences take place within the first year, postoperative follow-up should continue for at least 36 months.

Regarding Acucise endopyelotomy, recurrences seem to happen earlier, in the first 3–6 months after the intervention (Gill and Liao, 1998; Lechevallier et al., 1999).

Abstract

Infundibular stenosis is a rare pathological entity that can be congenital or acquired. The condition is the result of the obstruction of the caliceal infundibulum associated with hydrocalycosis, and requires a differential diagnosis with other pathological entities causing segmental dilations of the upper urinary tract: caliceal diverticulum and megacalycosis.

Keywords

caliceal diverticulum
caliceal infundibulum
calyceal
Fraley syndrome
hydrocalyx

11.1. Generalities

Infundibular stenosis is a rare pathological entity that can be congenital or acquired (Bodner et al., 1987; Husmann et al., 1994). The condition is the result of the obstruction of the caliceal infundibulum associated with hydrocalycosis, and requires a differential diagnosis with other pathological entities causing segmental dilations of the upper urinary tract: caliceal diverticulum and megacalycosis (Table 11.1).

Table 11.1

The Main Pathological Entities Characterized by Segmental Dilations of the Upper Urinary Tract

Condition	Features
Hydrocalycosis	Infundibular stenosis
	Caliceal dilation
	Renal papilla is present
Caliceal diverticulum	Nonsecreting urothelial cavities that are filled passively with urine from the adjacent collecting system
	Renal papilla is absent
Megacalycosis	Idiopathic caliceal dilation
	Absence of infundibular stenosis

Congenital infundibular stenosis is extremely rare and is usually associated with other dysplastic lesions of the urinary tract: multicystic renal dysplasia, contralateral renal agenesis, megaureter, and hydronephrosis. Most authors consider that this condition is secondary to the hypertrophy of the infundibular smooth muscle fibers or to extrinsic vascular compression (Boyce and Whitehurst, 1976; Kelalis and Malek, 1981). Histopathological examination can reveal large areas of cystic dysplasia proximal to the stenosis, thus differentiating the congenital type from the acquired one (Husmann et al., 1994).

Acquired infundibular stenosis can be intrinsic or extrinsic. Extrinsic vascular compression (by crossing renal vessels at the upper pole) can cause an infundibular stenosis associated with Fraley syndrome (Fraley, 1966). Other etiological causes of extrinsic infundibular stenosis are represented by trauma or neoplastic lesions (Bellman et al., 1994). Secondary intrinsic stenoses may occur after (Hwang and Park, 1994; Kim and Gerber, 2000):

- chronic inflammatory disorders (tuberculosis)
- malignancies
- posttraumatic vicious scarring
- impacted lithiasis
- percutaneous nephrolithotomy

The stones impacted in the caliceal infundibulum can cause an important secondary edema. The stone's removal determines, in most cases, the remission of the edema with repermeabilization of the caliceal infundibulum, without the need for another therapeutic procedure. However, a secondary infundibular stenosis can occur in some cases after the treatment of an impacted stone. Hence, Parsons described a 2% incidence of infundibular stenosis after percutaneous nephrolithotomy (Parsons et al., 2002). The main risk factors for this complication are: prolonged intervention, large calculi (which required multiple procedures), and maintaining the nephrostomy tube for a longer period of time. The percutaneous access area is the most frequent site for the development of infundibular stenoses.

In cases with infundibular stenosis, the radiological examination shows segmental caliceal dilation and can be diagnosed by ultrasound, urography, or retrograde ureteropyelography. In patients with congenital stenoses, it is necessary to diagnose possible associated malformations (cardiovascular, gastrointestinal, bone and testicular cryptorchidism). In some cases, retrograde ureteroscopy with an eventual biopsy of the suspected lesions is necessary to exclude a malignancy that can determine infundibular stenosis (Kieran et al., 2006). Computed tomography can be useful for establishing the relationship between the studied area and the remaining renal parenchyma. Renal scintigraphy with forced diuresis can be useful for objectifying the caliceal infundibulum obstruction. The differential diagnosis includes other segmental caliceal dilations (megacalycosis), as well as mass lesions that can be localized at this level (parapyelic cysts and

11.2. Indications

Hydrocalycosis that is secondary to caliceal infundibular stenosis is characterized by the presence of normal urothelium that continues to produce urine, contributing to the development of symptoms. The main therapeutic indications are represented by:

- recurrent infection
- obstruction
- chronic pain
- decrease of renal function
- hematuria

Caliceal infundibular stenoses that are secondary to tuberculosis or lymphoma require specific treatment of the underlying disease. In cases without an obvious etiology, it is important to establish the type of infundibular stenosis as either acquired or congenital. The treatment of the unilateral congenital type does not seem to have obvious benefits over time (MacMahon, 1974; Husmann et al., 1994). The presence of bilateral hydrocalycosis can produce a secondary impairment of the renal function, sometimes requiring renal transplantation (Kelalis and Malek, 1981). Untreated, the acquired type can determine hydronephrosis or progressive hydrocalycosis with the impairment of renal function (Bodner et al., 1987; Husmann et al., 1994; Parsons

11.3. Techniques

The treatment of infundibular stenosis is similar to that of caliceal diverticulum (Fuchs and David, 1989; Bellman et al., 1993). The approach can be antegrade or retrograde. Surgical treatment is very rarely used, being reserved for neglected cases with atrophic renal parenchyma (surgical or laparoscopic partial nephrectomy) (Kieran et al., 2006).

The treatment's objective is the decompression of the dilated calyx, achieving its adequate drainage into the collecting system, and eventually the removal of the associated lithiasis (Lang, 1991).

Preoperative preparation is standard, with associated urinary infections requiring adequate treatment (they represent a relative contraindication for surgical intervention).

Choosing the optimal surgical technique depends on various factors:

- severity (degree) of the stenosis (observed radiologically)
- location of the stenosis
- technical equipment
- surgeon's experience

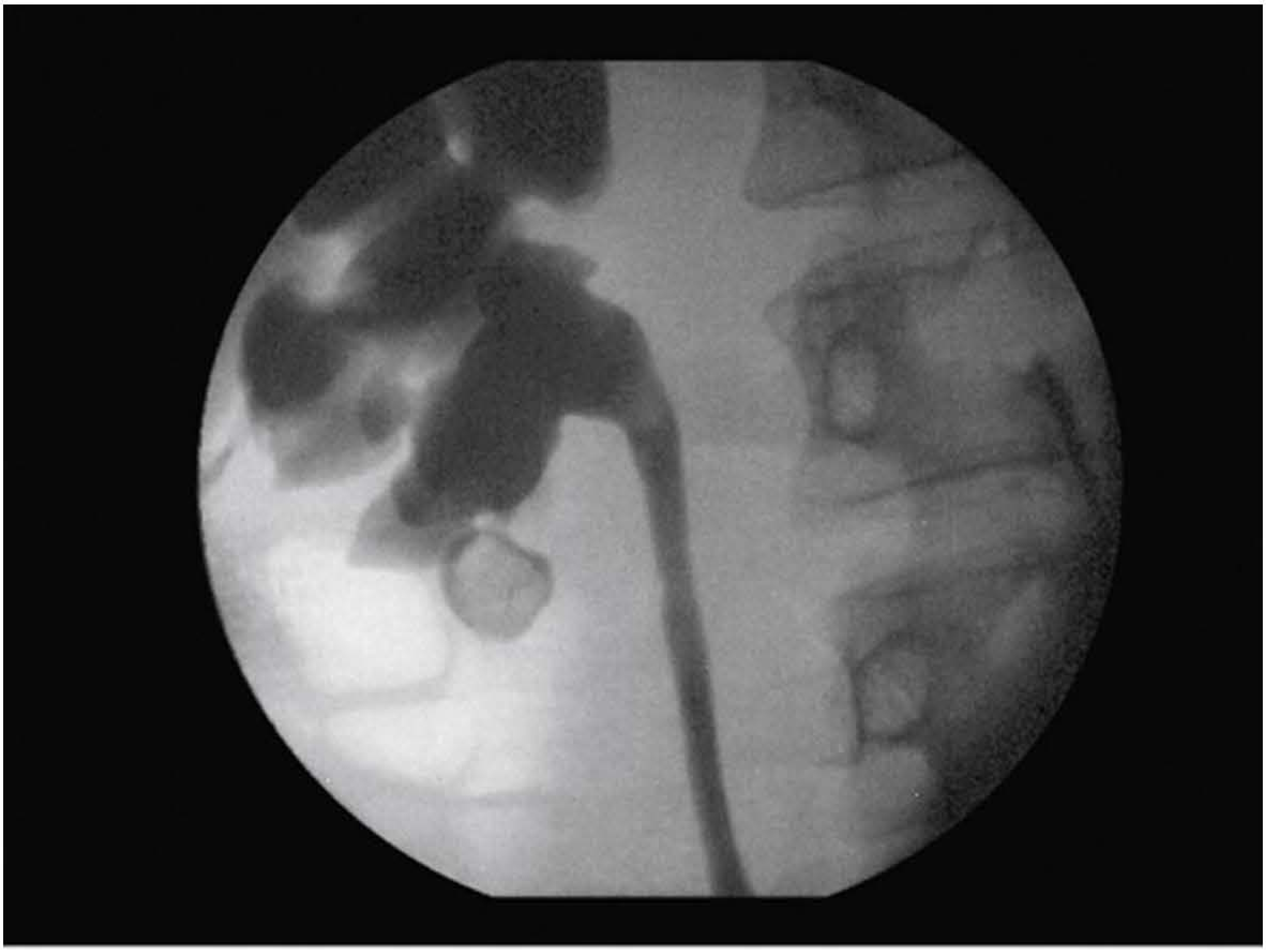
Locating the stenosis (in relation to the position of the renal artery) is very important for safely performing the surgical intervention. In order to avoid damaging an arterial branch, incision in the longitudinal axis of the infundibulum is recommended.

The therapeutic alternatives are differentiated according to the severity of stenosis. Hence, in practice, there may be two situations: stenoses that can be catheterized (allowing guidewire catheterization) and complete stenoses.

In the case of stenoses that can be catheterized, the endoscopic approach can be antegrade or retrograde.

The localization of the ostium in the renal collecting system, the reduced invasiveness, and an increased maneuverability of flexible ureteroscopes represent important factors that have allowed the use of the retrograde approach on an increasingly larger scale. The most important step of the intervention is to identify, with a guidewire, the ostium of the stenosed caliceal infundibulum and its catheterization. Most authors recommend the use of an additional safety guidewire. There are various ways to achieve a large communication between the dilated calyx and the rest of the pyelocaliceal system:

- balloon dilation (Geavlete et al., 2007) (Fig. 11.1)
- electrocautery incision using Greenwald or Hulbert electrodes
- Ho:YAG laser incision (Fig. 11.2)



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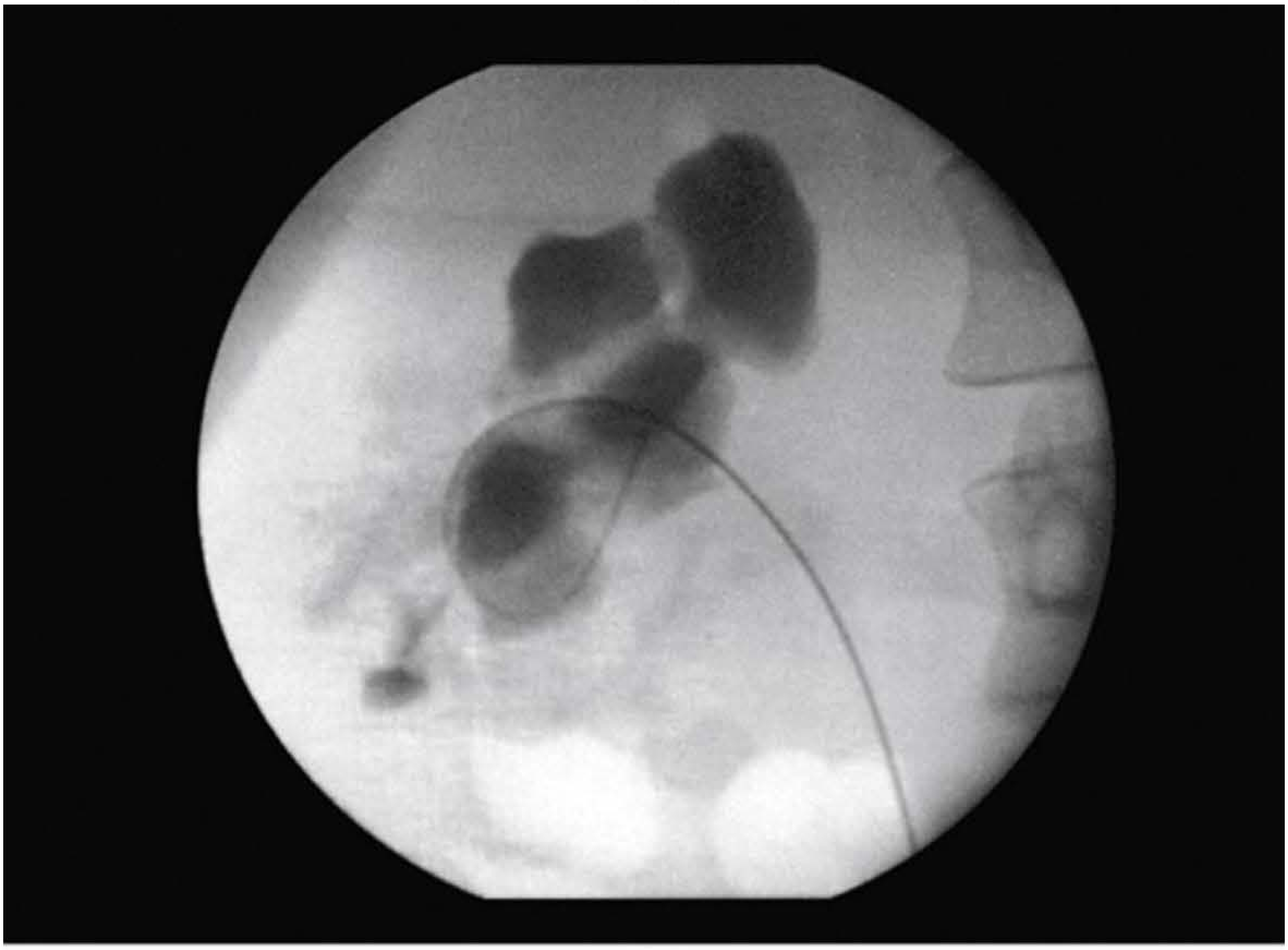

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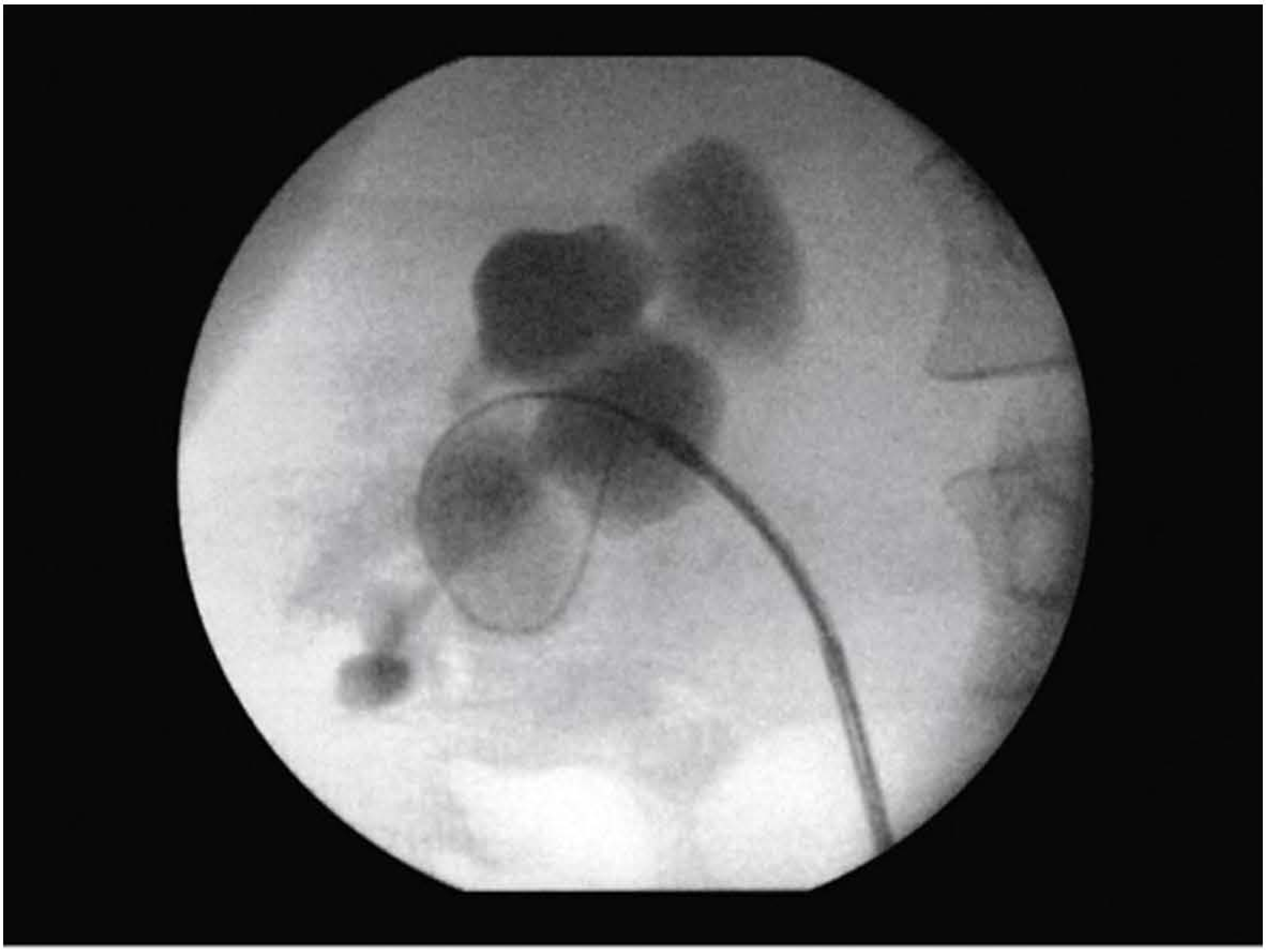

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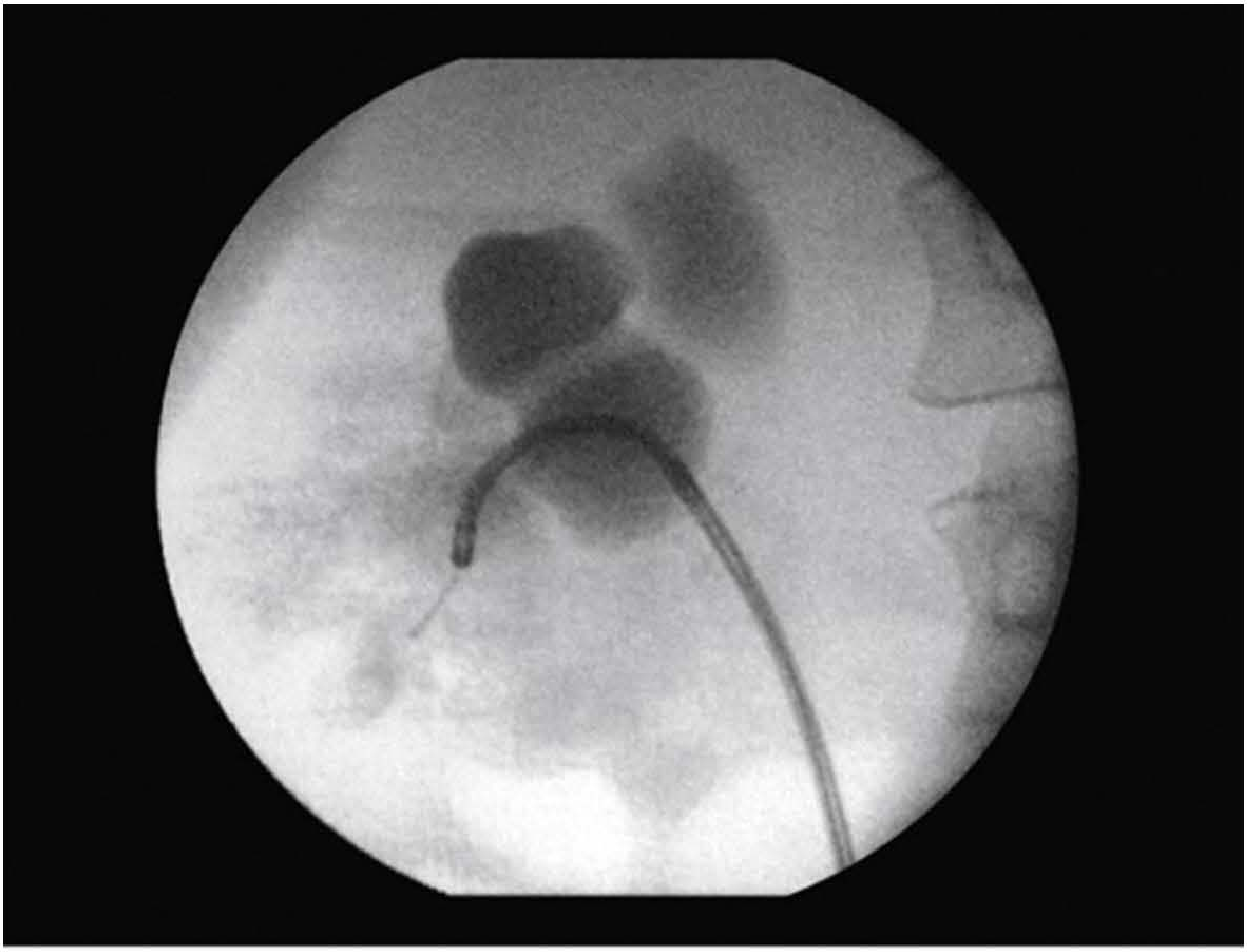

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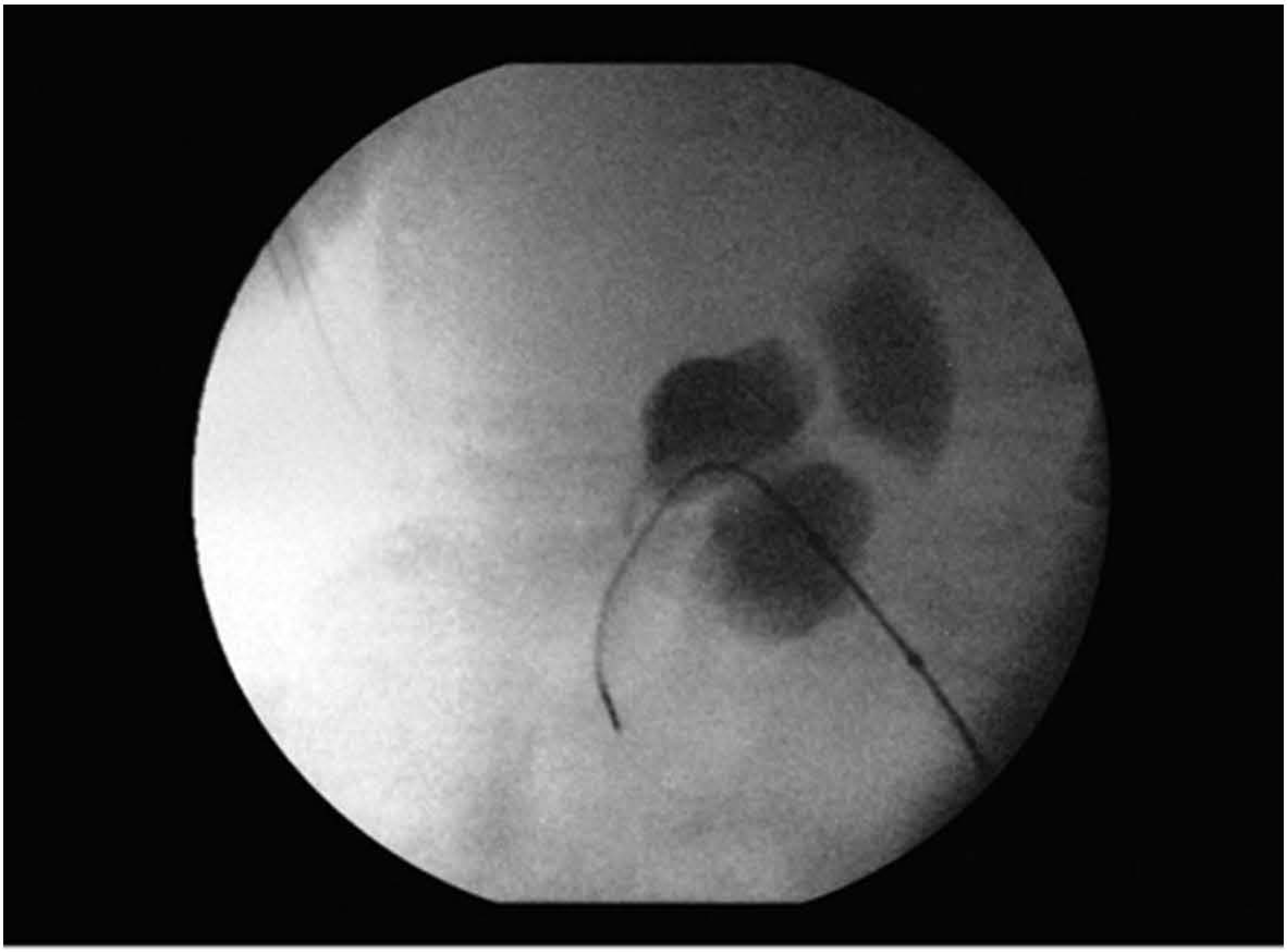

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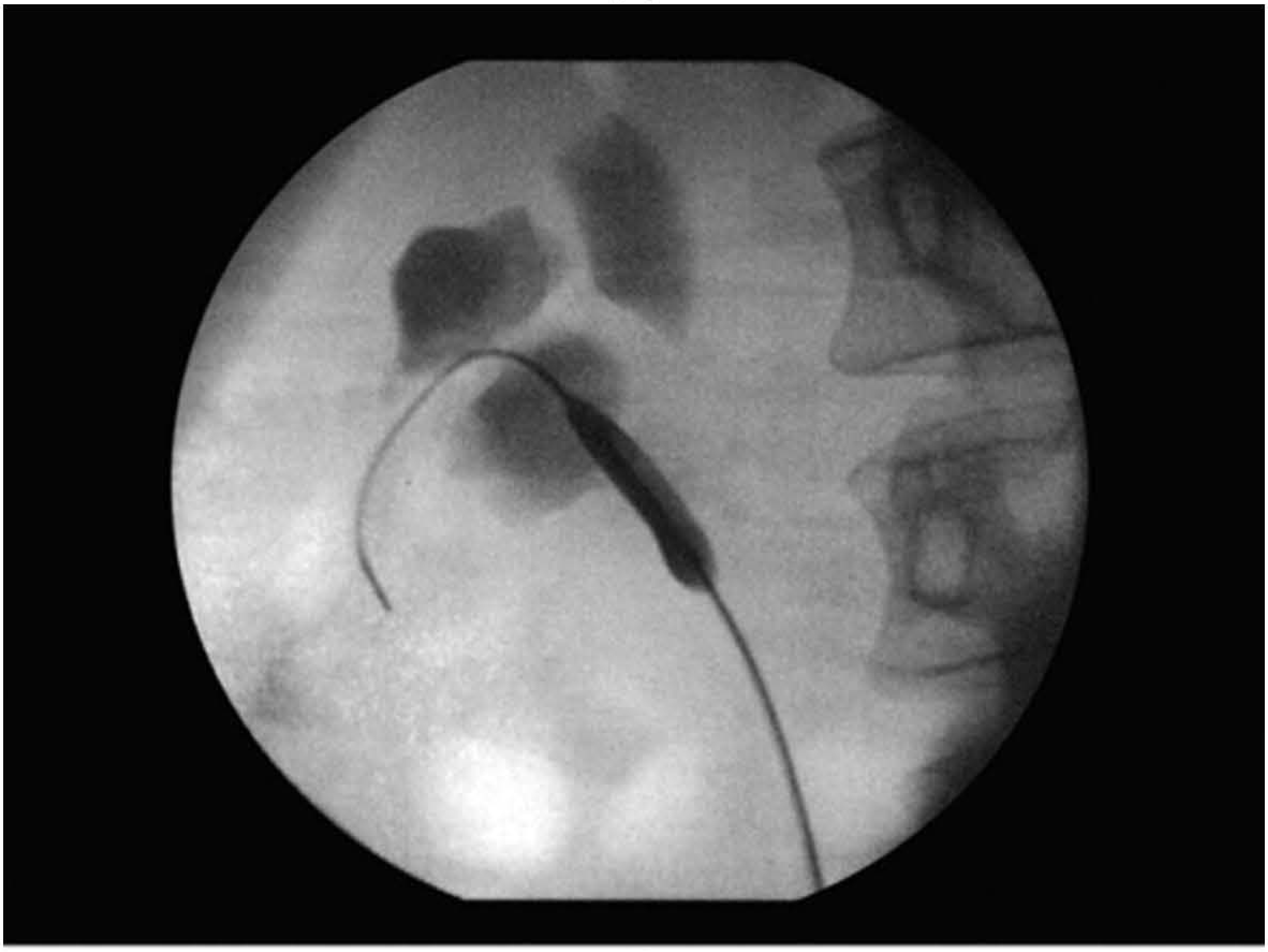

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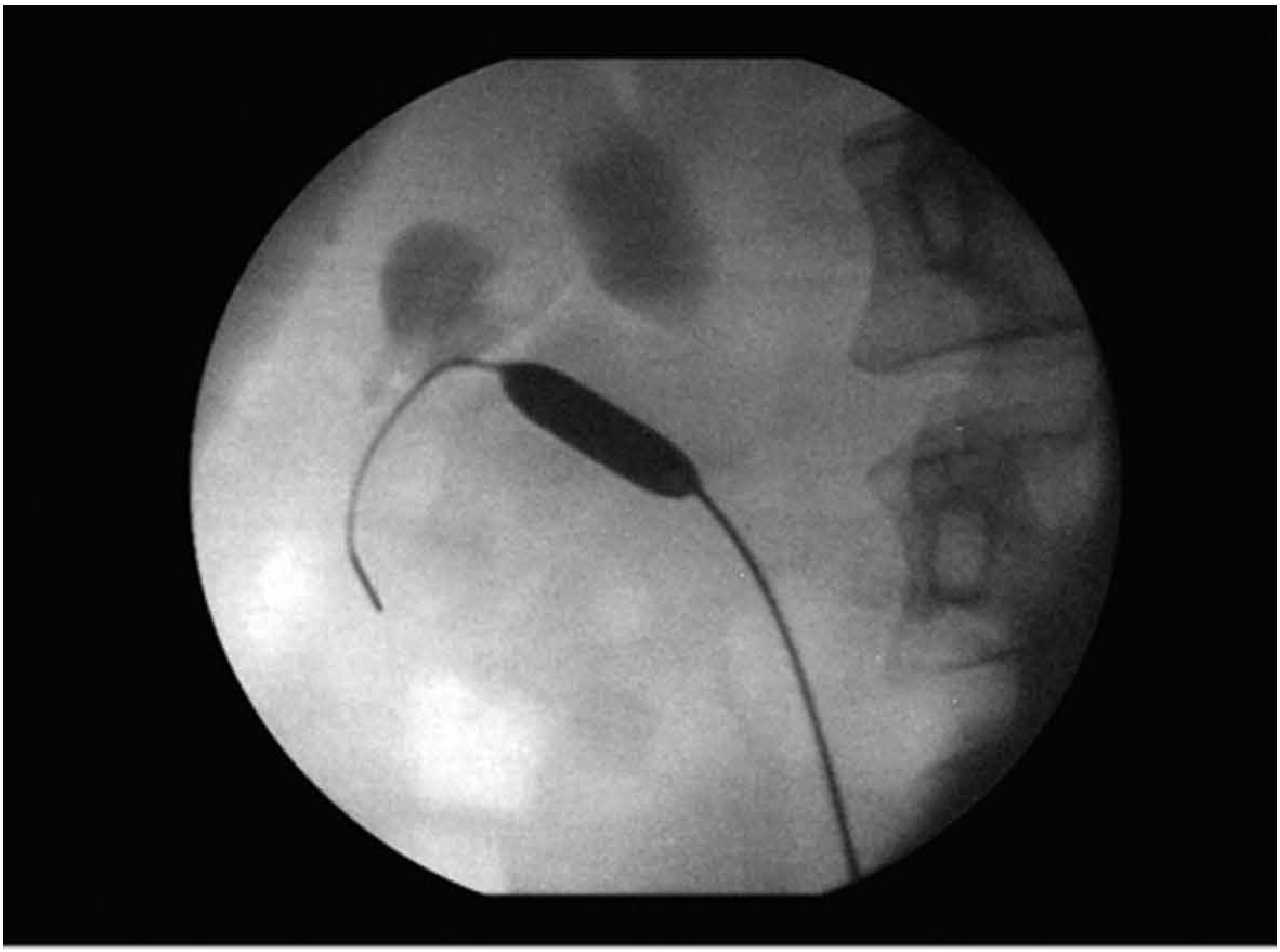

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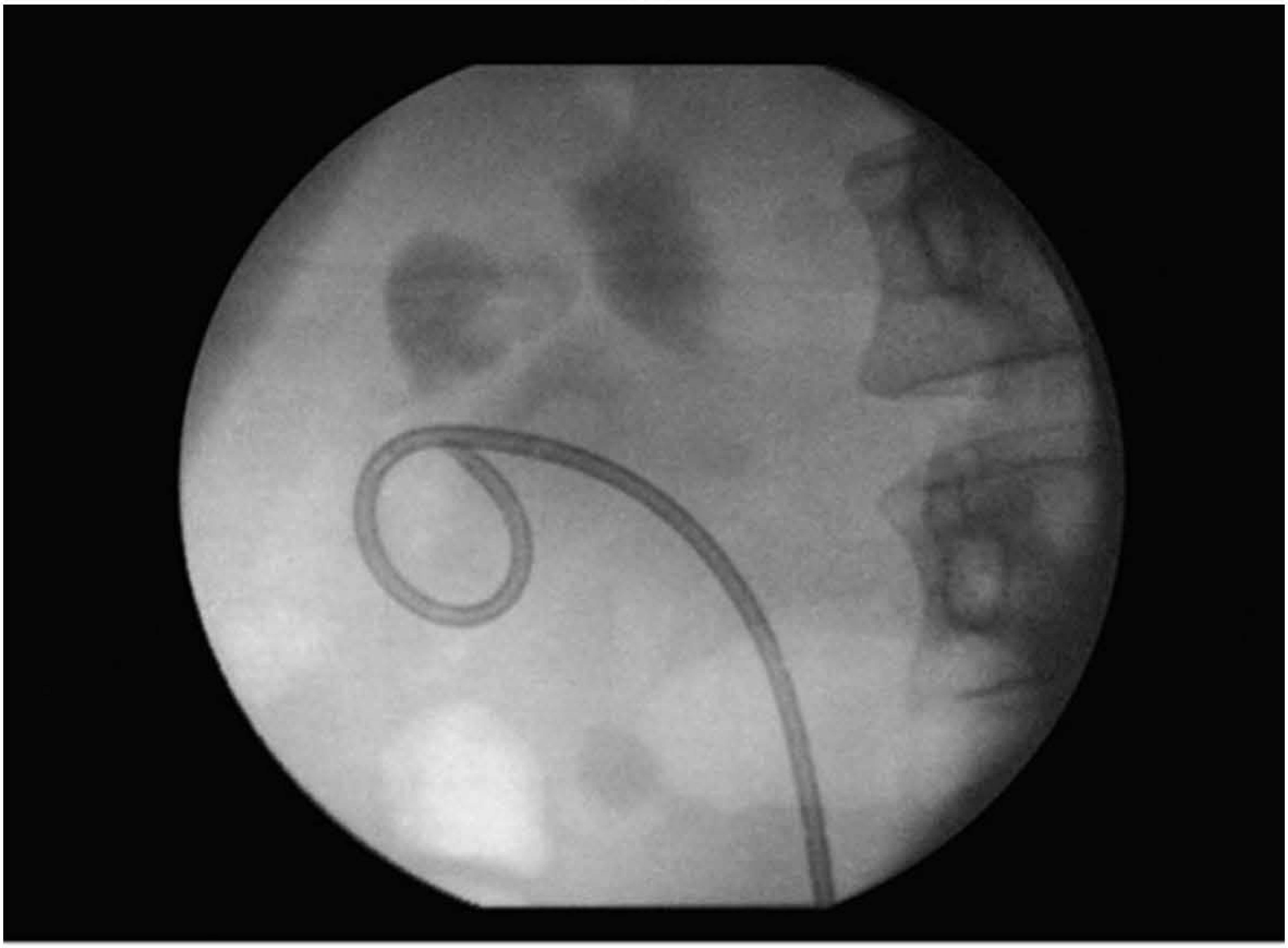

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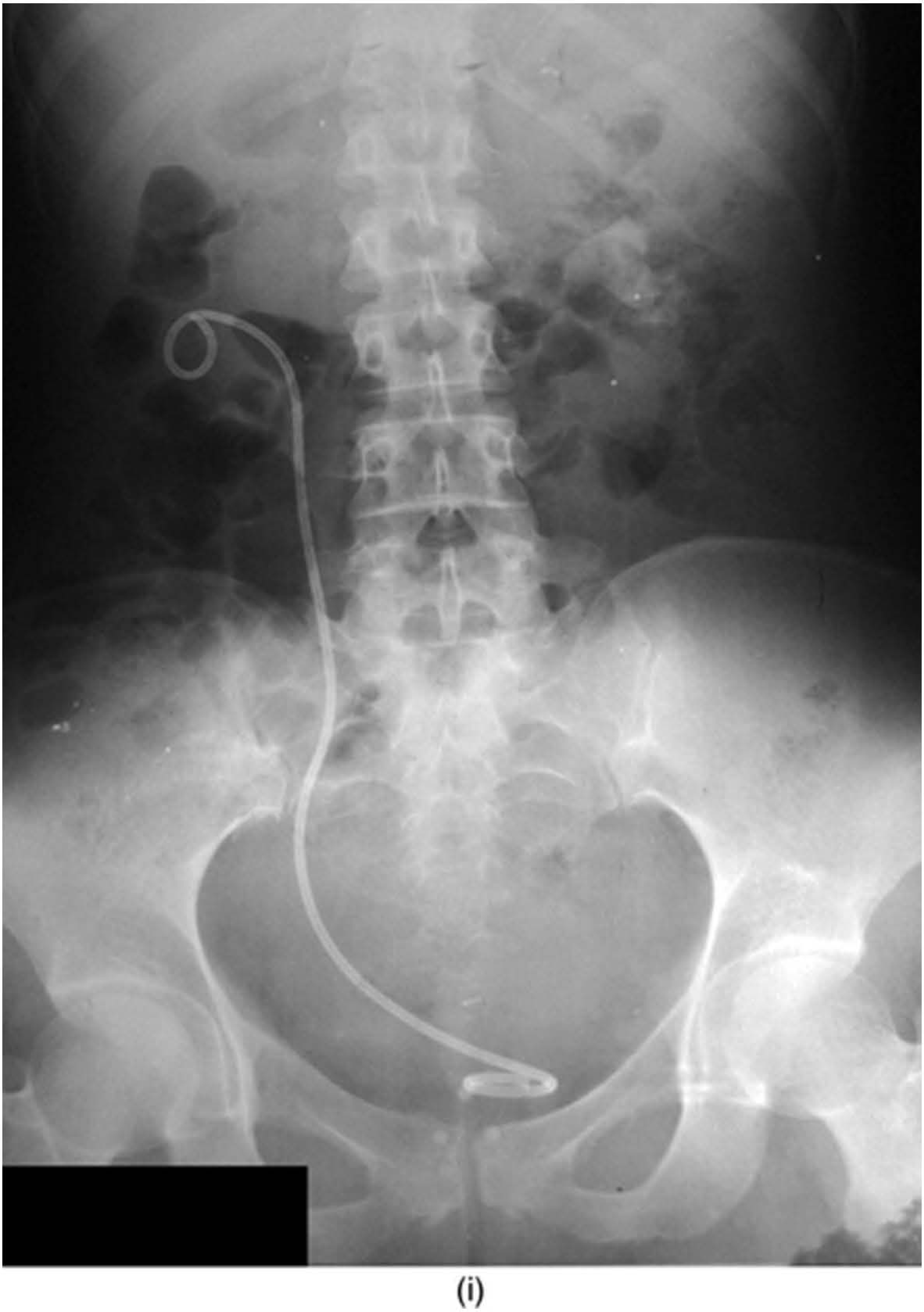
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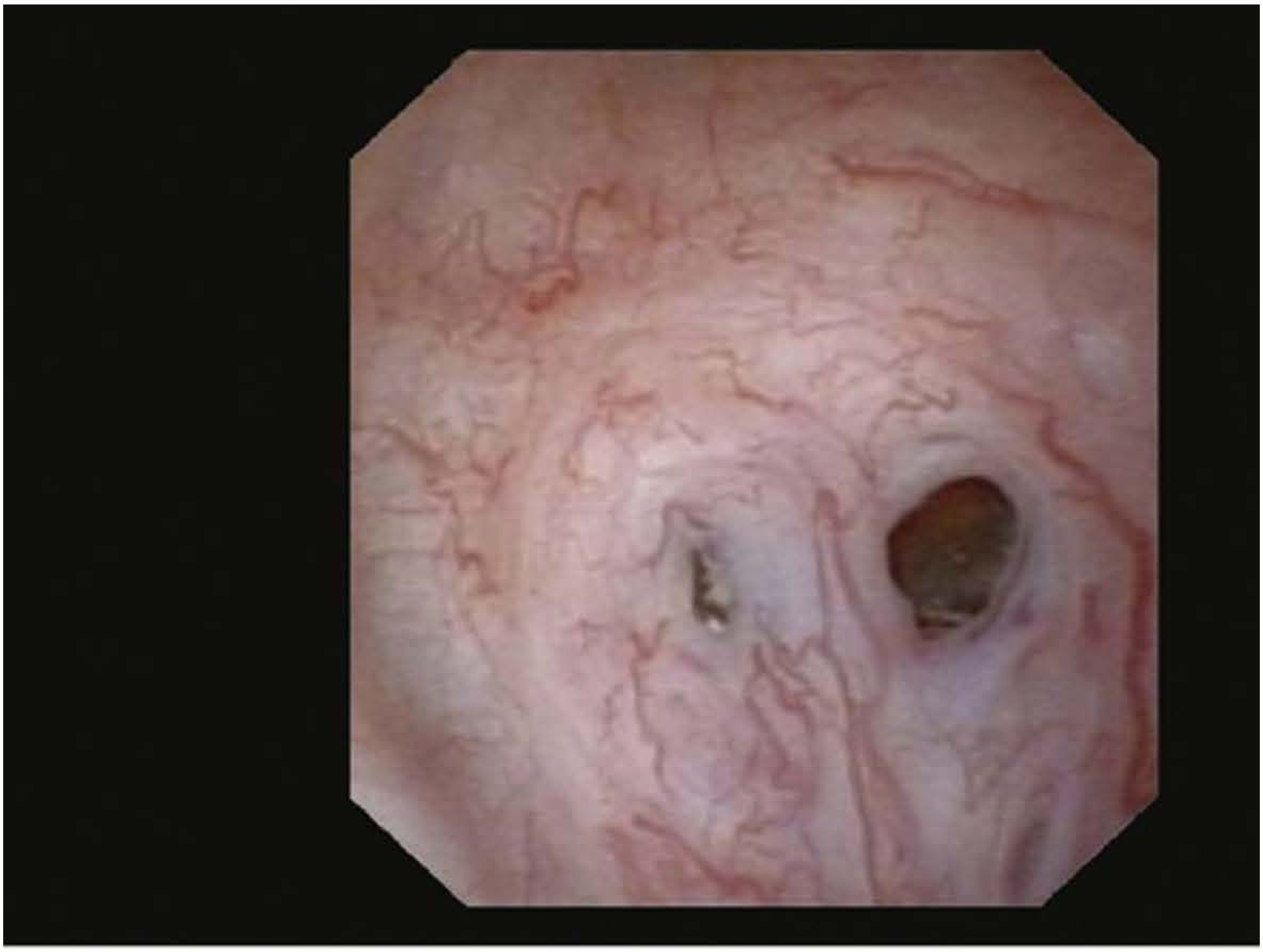
Figure 11.1 Retrograde ureteroscopic treatment of a middle caliceal infundibular stenosis. Persistent lumbar fistula after the percutaneous approach of a coraliform calculus (a), flexible ureteroscopic approach with the insertion of a guidewire into the middle calyx (b–d), balloon dilation of the stenosed caliceal infundibulum (e–g), and JJ stent placed in the middle caliceal group (h, i).



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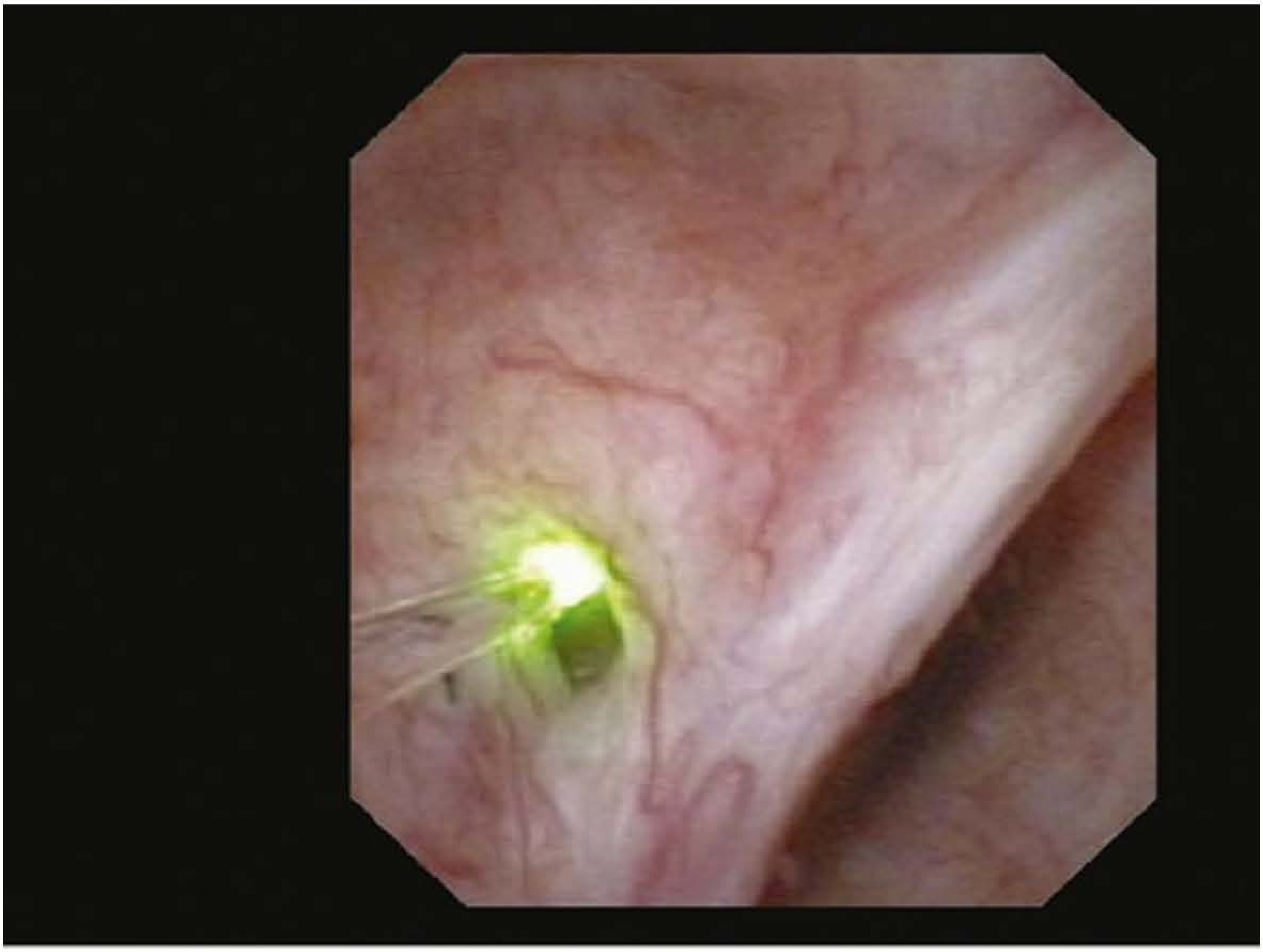

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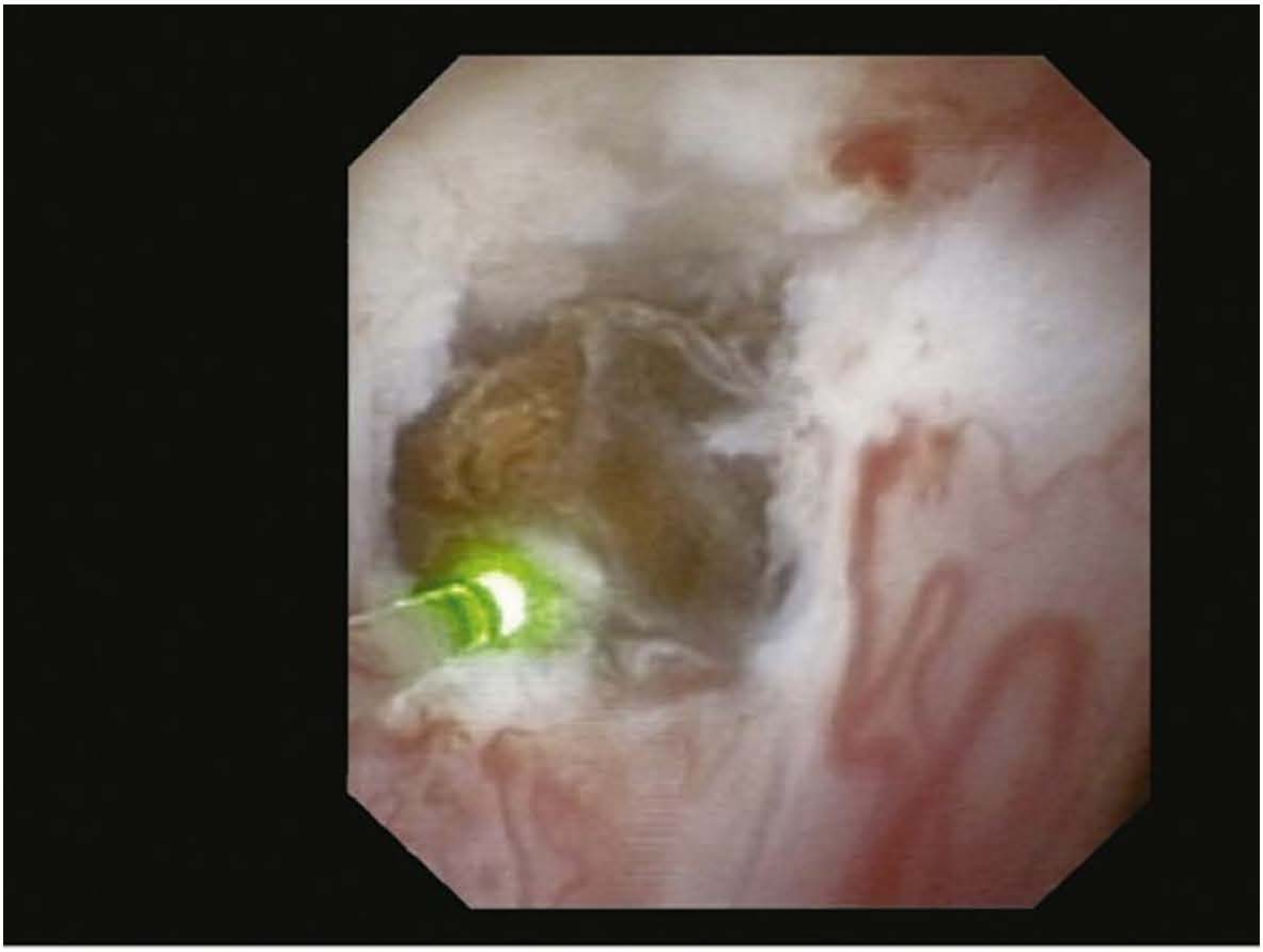

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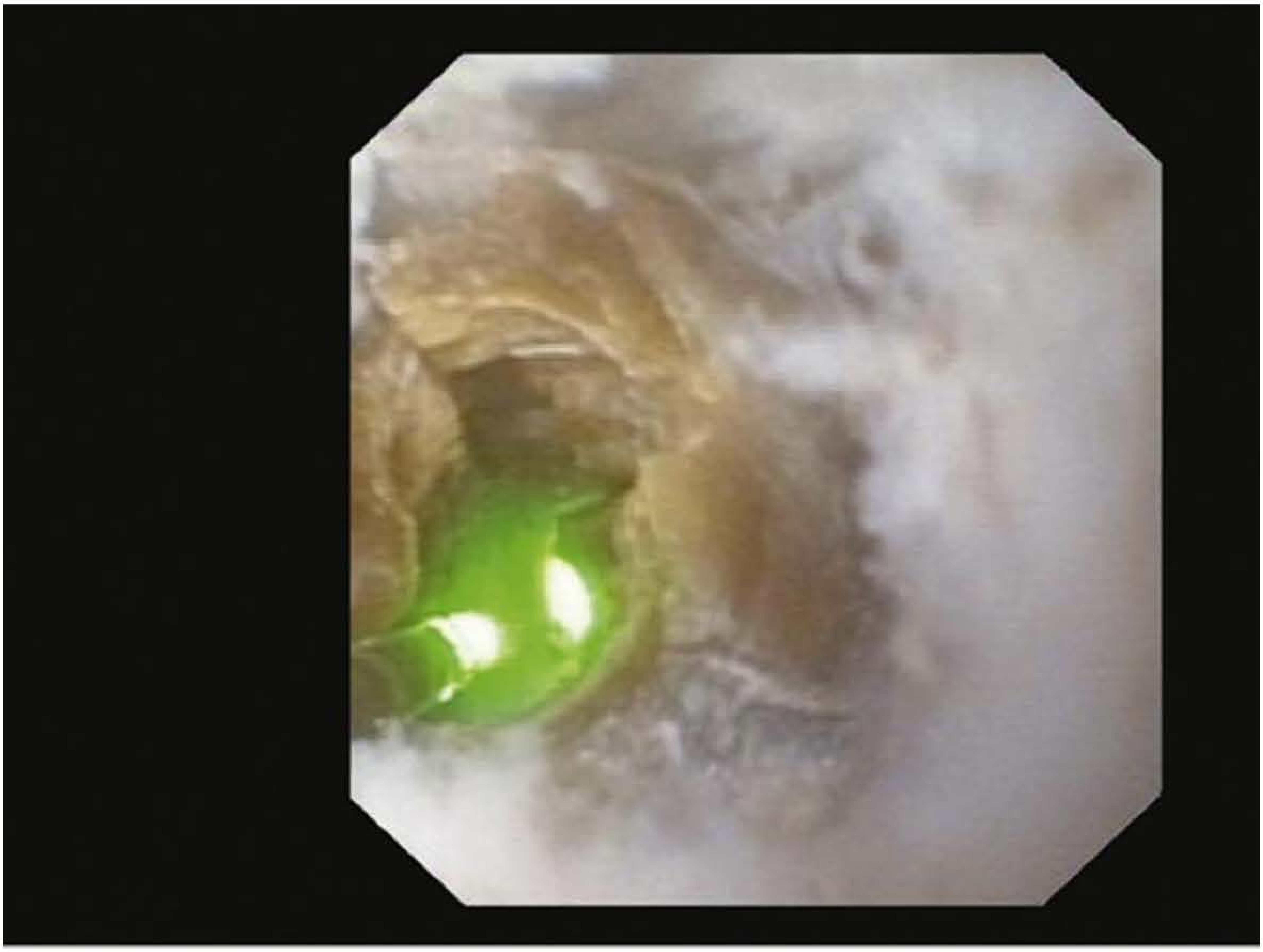

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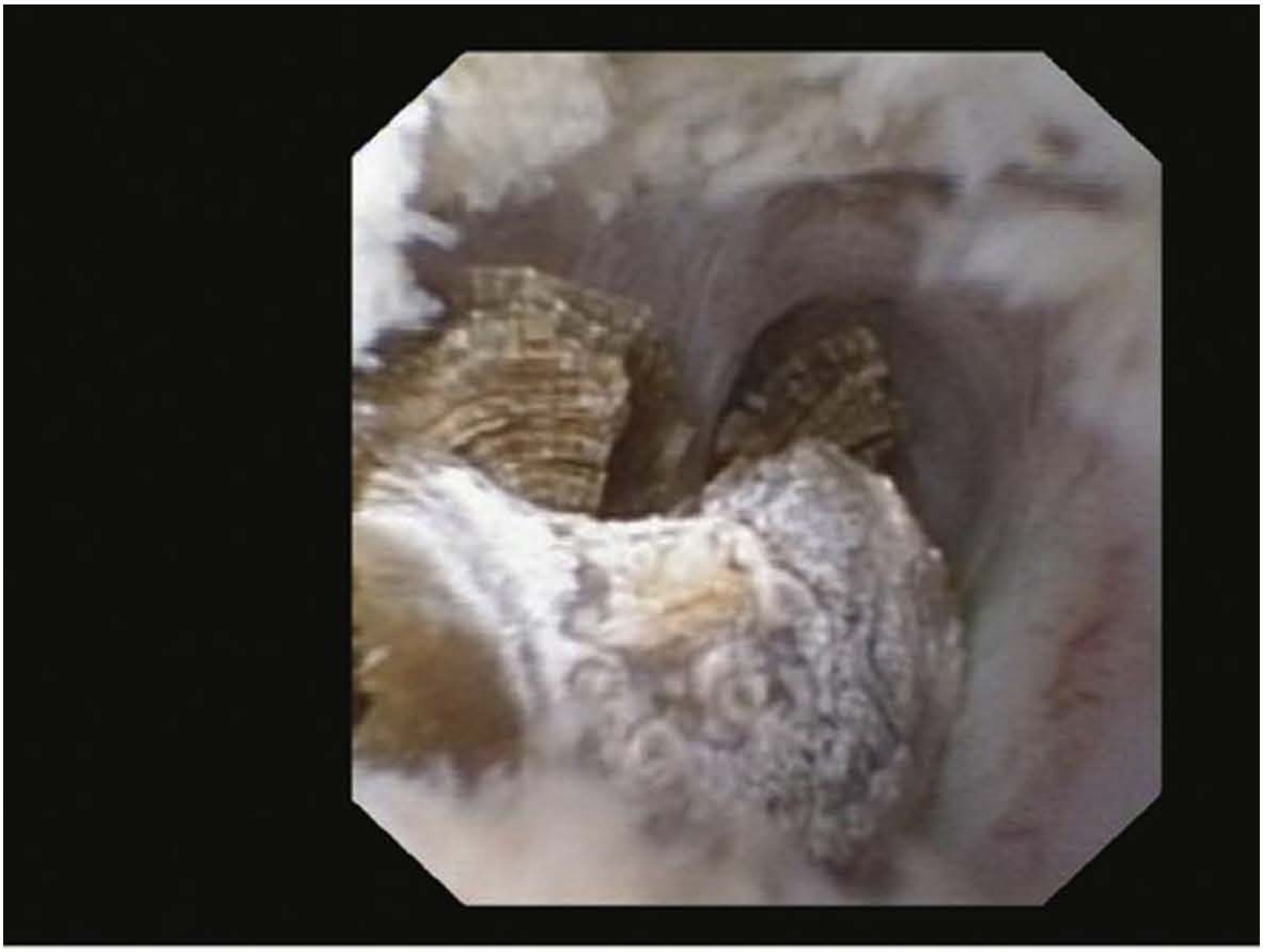

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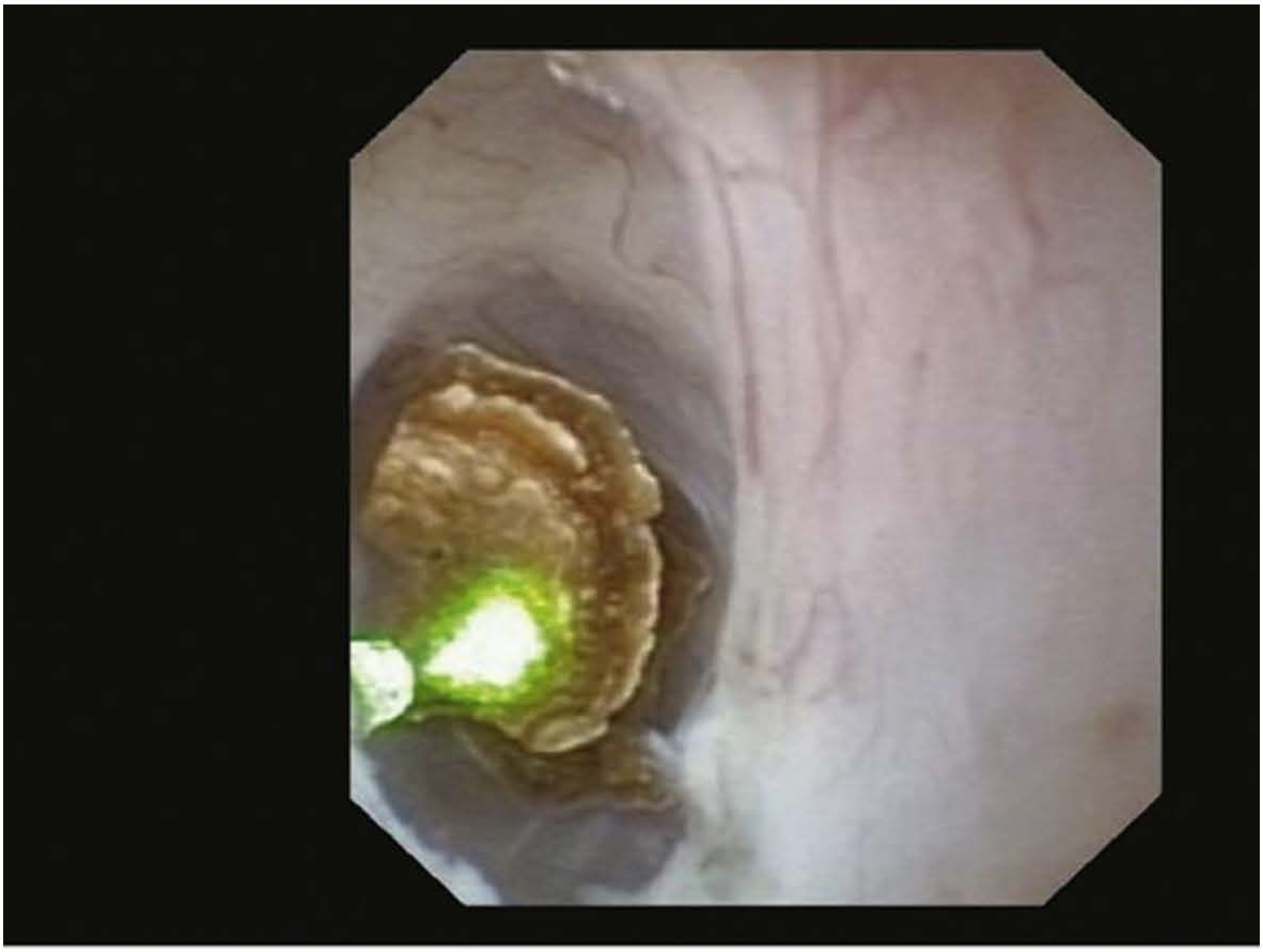

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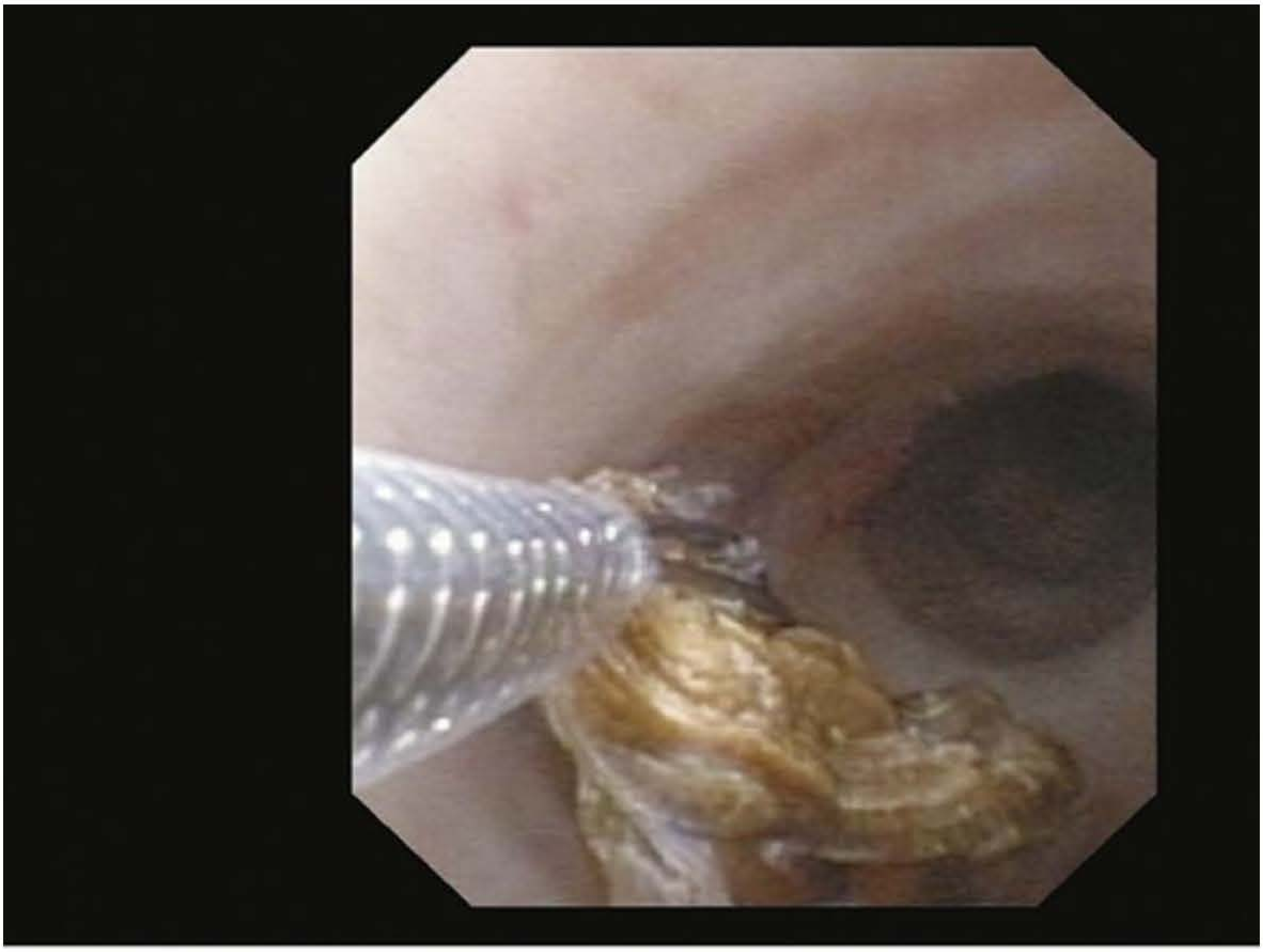

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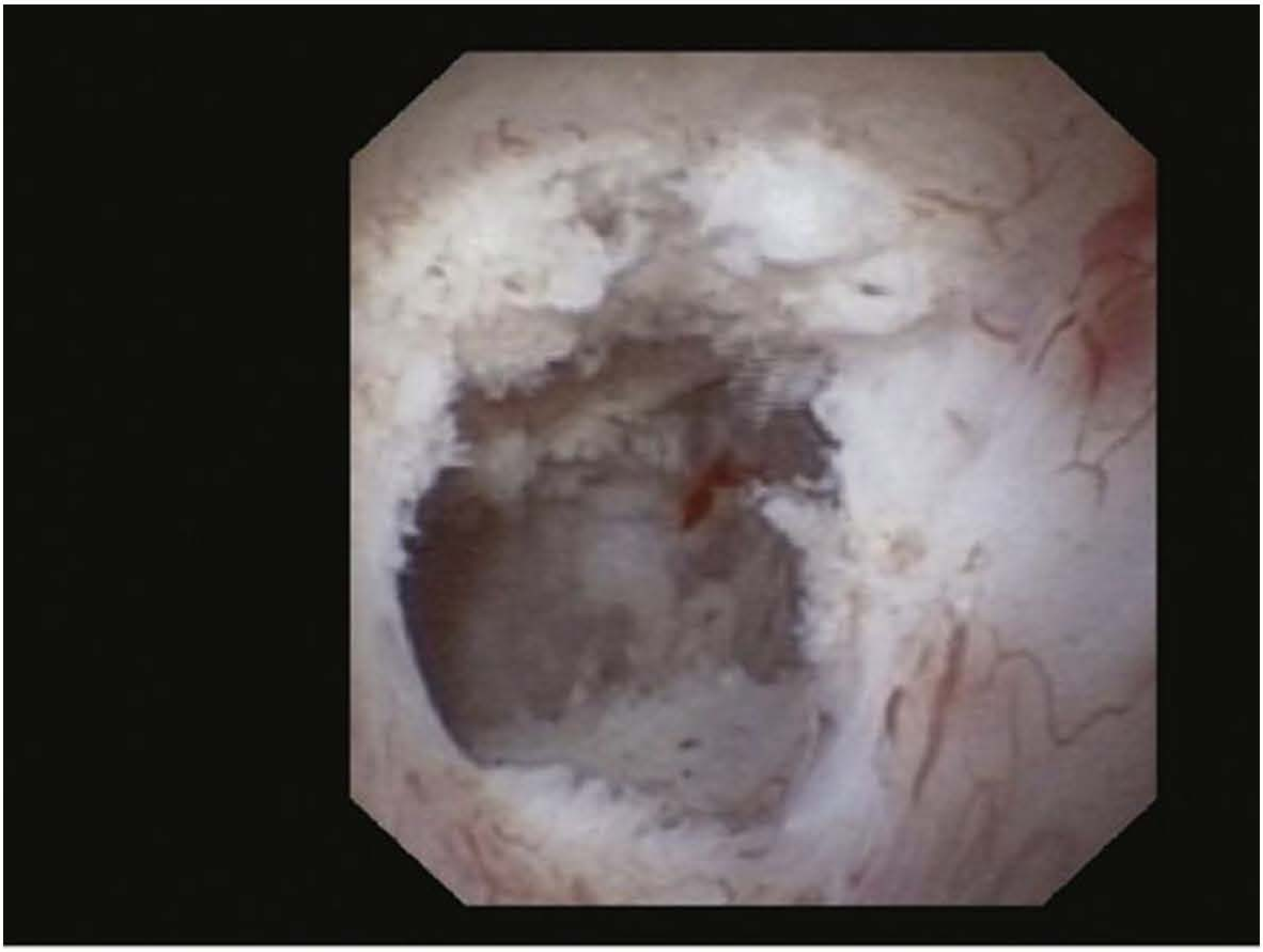
(h)

Figure 11.2 **Laser incision of the caliceal infundibular stenosis and the laser lithotripsy of associated lithiasis.**

When using electrocautery, it is recommended to set it to 50–75 W. Special attention should be paid to avoiding contact between the electrodes used for the incision and the metallic guidewire. This can be prevented by isolating the guidewire, which can be ascended through a ureteral catheter. If there is contact between the electrodes and the guidewire, then secondary lesions of the ureter, the urethra, and even the external genital organs can occur. Also, in the instance of a minor venous lesion, the use of electrodes to coagulate this area is contraindicated, because larger caliber vessels can be damaged, increasing the bleeding. Moreover, excessive use of coagulation can lead to tissue damage, with fibrosis and restenosis. Intraoperative arterial lesions require immediate detection and the performance of selective embolization (Auge et al., 2002).

The Ho:YAG laser is preferred by most authors, both because of the reduced diameter of the laser fiber (200 µm) that does not modify the deflection properties of the ureteroscope, and because of its properties (accurate incision, good hemostasis ability and the possibility of associated stone lithotripsy) (Kim and Gerber, 2000; Kieran et al., 2006) (Fig. 11.2).

After making the incision, dilation of the stenotic segment can be achieved with a balloon probe. The leakage of the contrast medium that is injected retrogradely confirms that the incision has been made correctly. At the end of the intervention (in the dilated calyx), the proximal end of a JJ catheter (8 F) or of a pyelostent (14/7 F) is placed. There is controversy regarding the optimal diameter of the stent and the period for which it should be maintained in place. Generally, internal drainage with a JJ catheter for 4–6 weeks is recommended.

There are particular situations in which only the passage of the contrast medium is possible, without managing to position the metallic guidewire. An antegrade approach is necessary in these cases. Injection of methylene blue-stained contrast media allows the opening site of the stenotic area to be detected, followed by positioning the guidewire and performing the incision. The incision is made after a careful inspection of the dilated calyx, in order to avoid the “pulsatile areas” located near the blood vessels (Lang, 1991). Electrocautery or, more modern, the Ho:YAG laser can be used for the incision (Kieran et al., 2006). A nephrostomy tube that passes through the incised area is placed postoperatively, which will be maintained for a period of 4 weeks. There is no consensus regarding its diameter; some authors recommending the use of a 24 F Malecot-type tube.

Additional orifices can be made to ensure an optimal drainage of the affected calyx (Lang, 1991).

Total obstruction of the caliceal infundibulum that does not allow the passage of the guidewire or the contrast media represents the most difficult situation encountered in practice. A combined antegrade and retrograde approach can be useful in this case. Thus, a guidewire can be inserted retrogradely and will be positioned in the immediate proximity of the stenotic area. Its movement can be monitored nephroscopically, with the incision being made in that area. However, this therapeutic alternative requires adequate instruments and an experienced surgeon who is knowledgeable about the local anatomy. Another alternative is represented by the “light” incision.

The prognostic factors that influence the long-term evolution are:

- degree of stenosis
- length of the stenotic segment
- associated fibrosis
- etiology of stenosis

The intra- or postoperative complications are generally minor and are specific to the type of approach used (Kieran et al., 2006). The most serious complication is represented by bleeding caused by the damage of a vessel during the incision. Arterial lesions may require selective embolization. Postoperative follow-up requires intravenous urography or contrast-enhanced computed tomography at 3, 6, and 12 months after the intervention.

11.4. Results

Due to the low incidence of this pathological entity, there are very few studies published (on a small number of cases with a short follow-up period). The most important series (10 patients) was published in 2006 by Kieran, who used a retrograde ureteroscopic approach for the treatment of hydrocalycosis secondary to infundibular stenosis. The retrograde approach of the stenotic area was possible in nine cases. In one case, with lower pole hydrocalycosis, an antegrade percutaneous approach was used. Incision was performed using the Ho:YAG laser (eight cases). Balloon dilation followed by electrocautery incision was used in two cases. Associated lithiasis was present in seven cases. Postoperative complications were minimal. The success rate (asymptomatic patients, without recurrence) was 50%, with five patients requiring repeating the procedure by an antegrade (four cases) or retrograde (one case) approach (Kieran et al., 2006).

Short stenoses, with minimal scars, have good results. Long stenoses with compact scars are much more difficult to treat, with low success rates. If a minimally invasive approach fails, these patients may require a much more aggressive management. Thus, sometimes classic surgical treatment is indicated: infundibuloplasty, ureterocalycostomy, or even partial nephrectomy (Gupta et al., 1980). The cases in which it is impossible to pass the guidewire through the stenotic area present the highest risk of recurrence. In these situations, long-term stenting may be an acceptable therapeutic alternative because open surgery is generally laborious and may lead to nephrectomy.

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Abstract

Iatrogenic ureteral lesions can occur as a complication of abdominal surgical procedures, but in most cases they are due to pelvic or retroperitoneal interventions. The widespread use of ureteroscopic and laparoscopic interventions has led to an increase in the incidence of secondary ureteral injuries.

Keywords

laparoscopic hysterectomy
electrocoagulation
ureteral crushing
ureteral devascularization
ureteral transection
intraoperative direct visualization
iatrogenic ureteral lesions
retrograde

12.1. Generalities

Iatrogenic ureteral lesions can occur as a complication of abdominal surgical procedures, but in most cases they are due to pelvic or retroperitoneal interventions.

The incidence of iatrogenic ureteral injuries varies between 0.5% and 30% (Gangai et al., 1976; Drake and Noble, 1998). Recent data indicate a decrease in their frequency to 0.1–2.5% (Sakellariou et al., 2002; Dorairajan et al., 2004). Ureteral lesions can be the result of multiple mechanisms:

- ligature
- elongation
- dilaceration
- devascularization
- avulsion

The widespread use of ureteroscopic and laparoscopic interventions has led to an increase in the incidence of secondary ureteral injuries (Assimos et al., 1994; Selzman and Spirnak, 1996).

Iatrogenic ureteral injuries represent approximately 75% of all ureteral trauma (Dobrowolski et al., 2002), the most important etiological factors being represented by:

- gynecological surgical interventions
- general surgery interventions
- urological interventions

The same author estimates a frequency of iatrogenic ureteral lesions after gynecological procedures of 1.6:1000. A relatively similar incidence (1.2:1000) was also described by Dorairajan at al. (2004). Regarding the location of the injuries, the pelvic ureter is most frequently affected (74%), followed by the middle ureter (13%) and the upper ureter (13%).

The most important published data regarding the etiology of iatrogenic ureteral injuries is summarized in Table 12.1.

Table 12.1

The Etiology of Iatrogenic Ureteral Injuries

Author	Number of cases	Etiology depending on the types of surgical procedures			
		Gynecological (%)	General (%)	Vascular (%)	Urological (%)
Selzman and Spirnak (1996)	165	34	17	7	42
Benchekroun et al. (1997)	39	84	3	8	5
Ghali et al. (1999)	32	63	7		30
Karmouni et al. (2001)	34	47	23	10	20
Dobrowolski et al. (2002)	340	73	14		13

The incidence of ureteral lesions after laparoscopic surgery varies between 1% and 2% (Ostrenski et al., 2003). Laparoscopic hysterectomy is the intervention that causes most iatrogenic injuries, especially in case of the extensive use of

12.2. Classification

Ureteroscopic procedures generally cause minor mucosal injuries or minimal ureteral perforations (Geavlete et al., 2004). These were described in detail in a previous chapter.

The use of small caliber instruments, as well as the more and more frequent use of flexible ureteroscopes, has led to a decrease in the incidence of these injuries (Preston, 2000).

The American Association for the Surgery of Trauma classifies ureteral injuries into five grades (Table 12.2).

Table 12.2

Classification of Iatrogenic Ureteral Injuries

Grade	Characteristics
I	Hematoma
II	Transection <50% of the circumference
III	Transection >50% of the circumference
IV	Complete transection with <2 cm devascularization
V	Complete transection with >2 cm devascularization

Although this classification is not used in practice, it is important for comparing the results from different published studies.

The classification most often used in practice is based on the mechanism involved.

12.2.1. Ureteral Ligature

Ureteral injuries occurring during vaginal surgical interventions are generally secondary to an accidental ligature and are usually detected after the procedure (Selzman and Spirnak, 1996). Most of them are the result of the failure to identify the ureter and occur during the hemostasis maneuvers (Neuman et al., 1991). Some authors recommend intravenous injection of indigo carmine and a cystoscopic control after interventions in the genital area. The absence of evacuation of dye through a ureteral orifice may allow the early diagnosis of an accidental ureteral ligature (Blandy et al., 1991).

12.2.2. Ureteral Crushing

The use of surgical clamps for hemostasis may determine ureteral crushing with significant injuries. This generally occurs during an attempt to stop the bleeding. In these cases, if the lesion is recognized during the intervention, the ureteral adventitia must be carefully examined because in many cases the ischemic lesions are important and can become evident only after several days. The severity of ureteral damage depends on the size of the clamp, on the moment when the clamp was applied, and on the mass of the crushed tissue. Placement of a JJ catheter is sufficient for minor lesions, while important injuries may require segmental ureteral resection.

12.2.3. Ureteral Devascularization

In general, lesions with ureteral devascularization are recognized late, when they are complicated by fistulas or ureteral strictures (Al-Ali and Haddad, 1996). When ureteral thermal injuries or extensive ureteral skeletonization are identified during the intervention (possibly affecting viability), excision of the affected segment is recommended. Viability is difficult to assess in most cases. In case of any doubts, it is recommended to place a ureteral endoprosthesis.

12.2.4. Partial or Complete Ureteral Transection

Most partial transections occurring during surgical interventions can be treated by primary suture and internal drainage with a JJ catheter. If more than half of the ureter's diameter is affected, some authors recommend segmental ureteral

12.3. Diagnosis

Intraoperative direct visualization of the lesion represents the ideal diagnostic method. Most authors insist on the importance of early diagnosis (ideally during the intervention) of iatrogenic lesions. Unfortunately, only 20–30% of iatrogenic ureteral lesions are diagnosed during surgery, most of the time the diagnosis being established late, sometimes due to the secondary complications (urinomas, stenoses, fistulas).

The diagnosis is suggested by the postoperative occurrence, usually after 5–7 days, of signs and symptoms of unilateral ureteral obstruction: lumbar pains, oliguria or anuria (in bilateral injuries), fever, increase in azotate retention values, hematuria, uretero-vaginal fistula. The injury may be discovered accidentally in some cases. Imaging diagnosis is very important. Thus, abdominal ultrasonography may reveal dilation of the pyelocaliceal system and of the proximal ureter in case of ureteral ligature or of a stenosis developed late after the intervention. Doppler ultrasonography can detect the absence of ureteral flow on the affected side. Intravenous urography allows the visualization of the ureteral obstruction or the leakage of the contrast agent. Computed tomography is required in cases with an uncertain diagnosis. Retrograde pyelography (Fig. 12.1) represents the "gold-standard" investigation for the diagnosis of iatrogenic injuries.

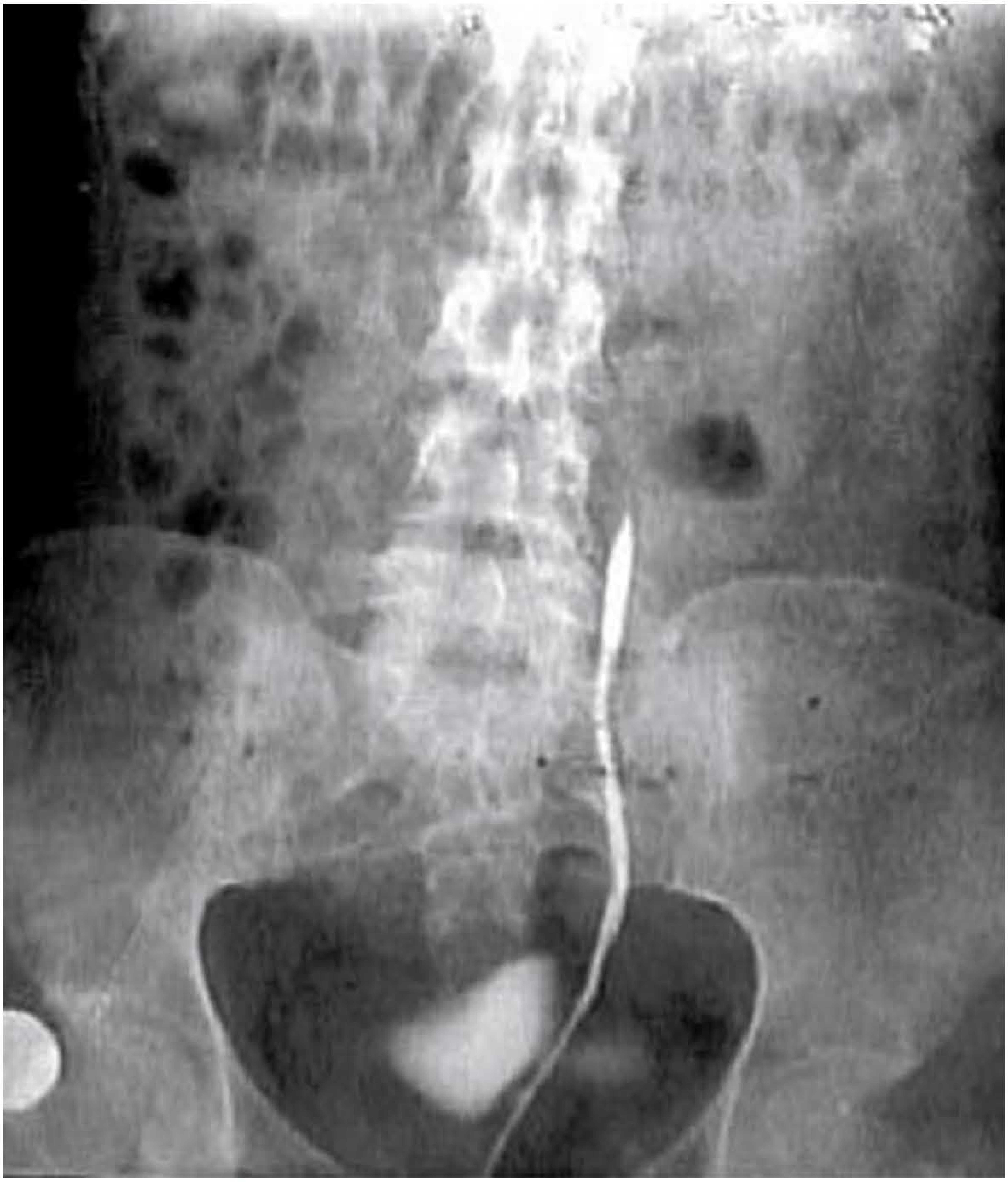

Figure 12.1 Ureteral ligature (retrograde ureteropyelography).

12.4. Therapeutic options

Choosing the optimal therapeutic alternative for an iatrogenic ureteral injury is influenced by several factors:

- location and length of ureteral damage
- moment of diagnosis (intraoperatively, immediate, or late postoperatively)
- type of lesion and the etiopathogenic mechanism involved
- presence of comorbidities

The main therapeutic options are represented by minimally invasive treatment and open reconstructive surgery. The management of iatrogenic ureteral injuries is differentiated according to the moment of diagnosis: early or late.

12.4.1. Early Treatment

The optimal moment for treating iatrogenic ureteral lesions is during the surgical intervention (the one that was complicated by the ureteral injury). Thus, the occurrence of scarring and of complications can be avoided (this can reduce the success rate in case of a late intervention).

Unfortunately, most iatrogenic ureteral lesions (over 65%) are diagnosed late (Neuman et al., 1991), often requiring complex interventions. Sometimes renal function can be impaired irreversibly, with possible medicolegal implications (Preston, 2000).

When the iatrogenic lesions are identified during surgery, depending on the type of injury, the therapeutic alternatives may be represented by the following:

- urinary derivation
- segmental ureteral resection with termino-terminal anastomosis
- ureteral reimplantation

The early treatment of iatrogenic lesions will be differentiated according to the severity of the lesion and to its location (Utrie, 1998) (Table 12.3).

Table 12.3

Early Treatment of Iatrogenic Ureteral Injuries

Iatrogenic lesion	Early treatment
Ureteral ligature	Removal of the ligature and internal drainage with a JJ catheter
Ureteral crushing	Ureteral endoprosthesis
	Percutaneous nephrostomy
Transection of the lumbar or iliac ureter (lesion under 3 cm)	Termino-terminal anastomosis and internal drainage for 4 weeks with a JJ catheter
Transection of the distal ureter (lesion greater than 5 cm)	Uretero-vesical reimplantation (Leadbetter–Politano, Lich–Gregoir) or ureterocystoneostomy
Any iatrogenic injury during a laborious surgical intervention in a patient with associated comorbidities	Urinary derivation (percutaneous nephrostomy) with reevaluation and treatment in a second step

12.4.2. Late Treatment

Usually, in patients with a late diagnosis of iatrogenic ureteral injuries, the treatment is addressed to the complications: ureteral stenosis, ureteral fistula. Thus, two therapeutic options are described: open surgery and ureteroscopy with endoureterotomy.

Although stenoses secondary to iatrogenic lesions have etiopathogenic mechanisms similar to the other ureteral strictures, when complete, they represent a pathology that is far more difficult to treat.

Although open surgery is still the most commonly used therapeutic option, it implies a prolonged hospitalization period, significant morbidity, and high costs (Ku et al., 2003). Therefore, many authors prefer endourological treatment as the first alternative (Knowles et al., 2001; Geavlete et al., 2006).

The natural evolution of ureteral ligatures with absorbable threads tends toward their absorption over time. Therefore, placing a percutaneous nephrostomy with the patient's subsequent surveillance (wait and see) may be an appropriate therapeutic conduct (Harshman et al., 1982). Thus, some studies show a rate of spontaneous recovery of ureteral integrity of about 80% (Lask et al., 1995). When using absorbable threads, an early ureteroscopic approach with their incision is recommended (Fig. 12.2).

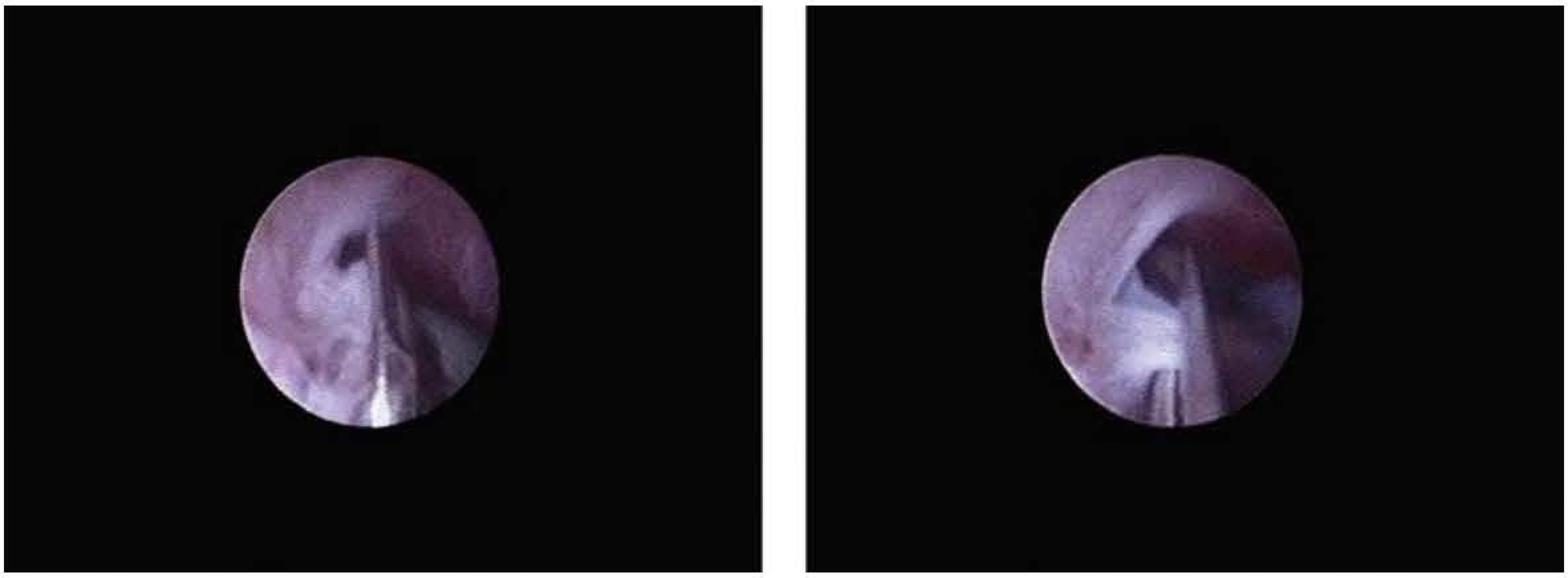

Figure 12.2 **Ureteroscopic incision of a nonabsorbable transfixiant thread.**

The endourological options are different according to the operator's personal experience and preference. Cold-knife (Fig. 12.3) or laser endoscopic incision, as well as the use of balloon dilation can determine acceptable results.

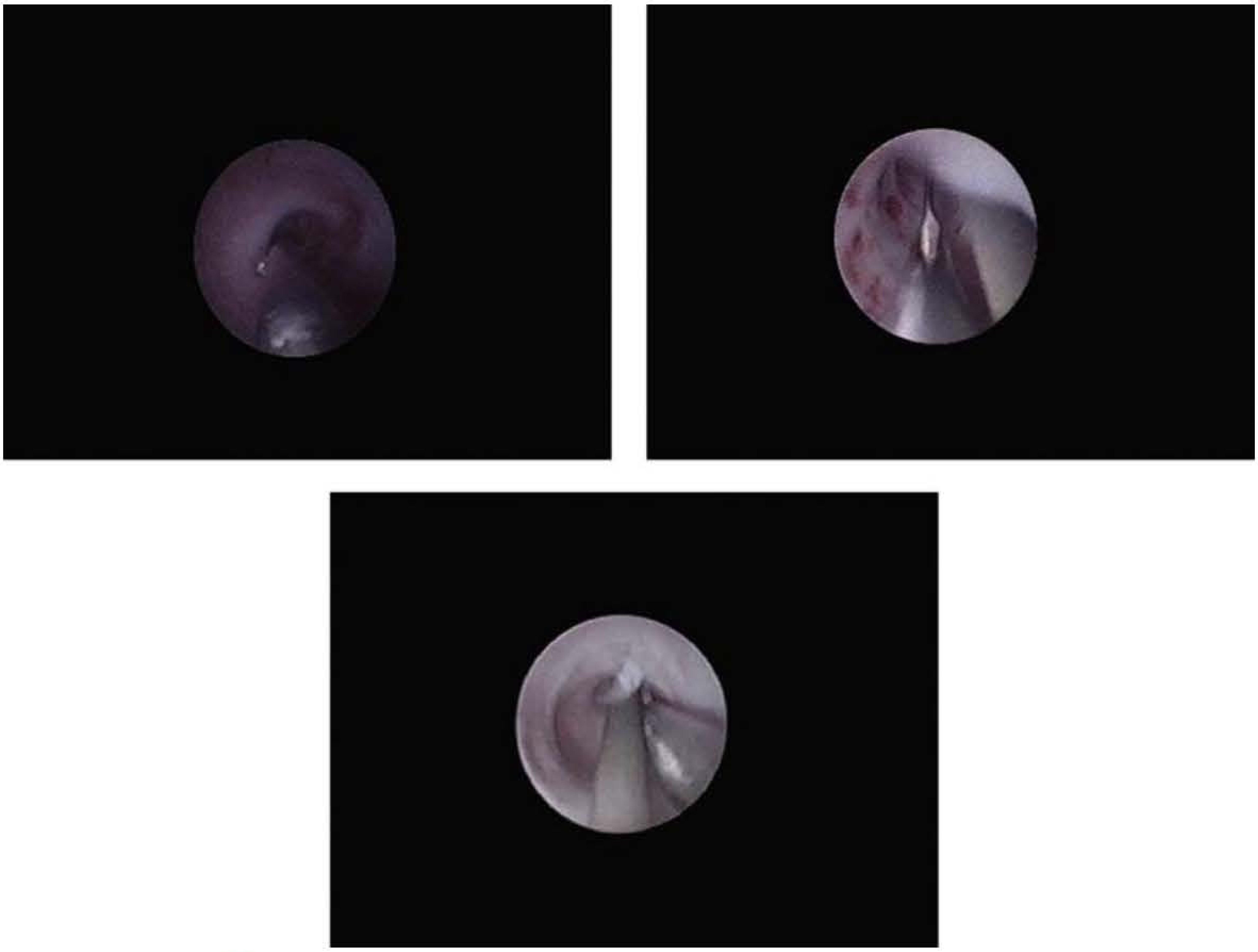

Figure 12.3 **Cold-knife endoureterotomy for iatrogenic ureteral stenoses.**

The success rates vary between 61% and 78%, depending on the age of the patients and on the length of the stricture (Seseke et al., 2002).

In cases with complete ureteral obstruction (Fig. 12.4), endoureterotomy by combined approach (antegrade and retrograde) and incision in light (cut-to-the-light) may represent an alternative with satisfactory results, the success rate reported in the literature being approximately 70% (Tsai et al., 2000).

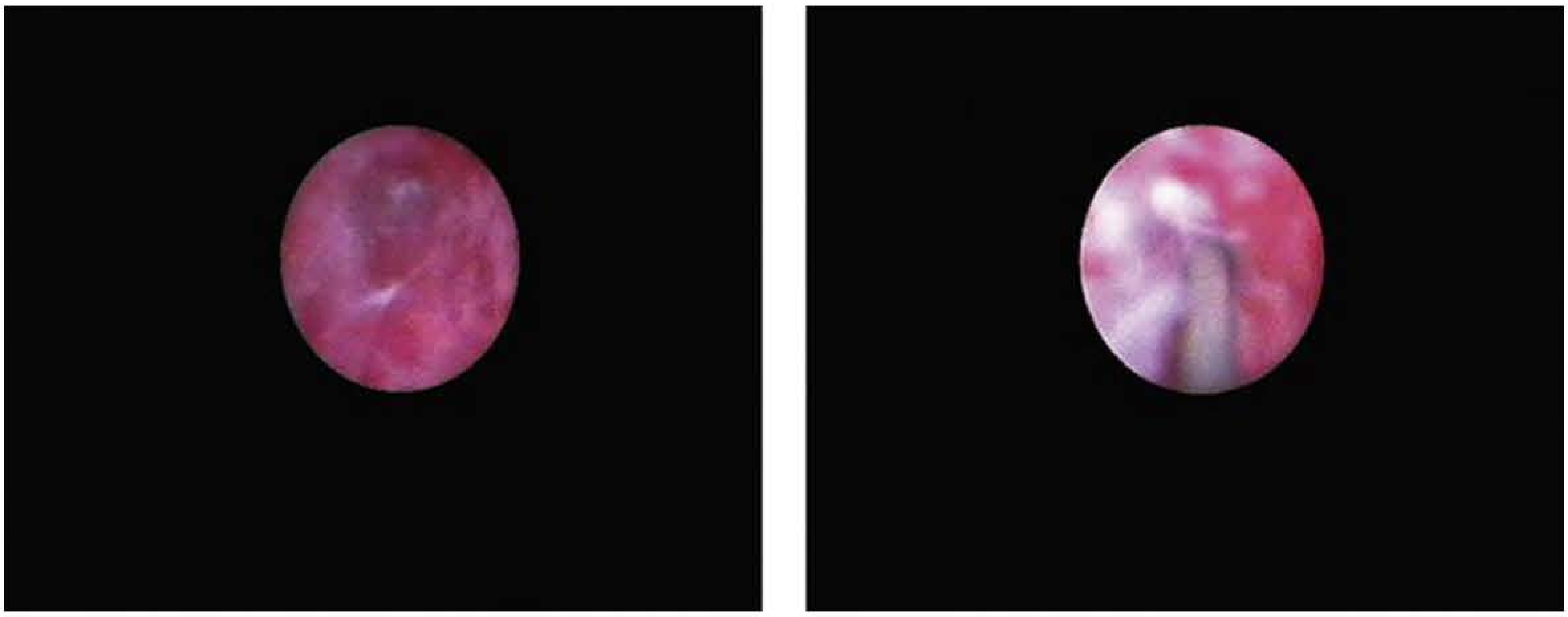

Figure 12.4 **Complete iatrogenic ureteral stenosis.**

Generally, the ideal candidates for endoscopic management are represented by patients with short iatrogenic stenoses (under 2 cm) (Geavlete et al., 2003). The optimal moment of the intervention is still a controversial issue. Thus, some authors recommend the late approach, after 3–6 months, in order to allow for the regression of regional edema and for complete suture absorption (Sakellariou et al., 2002; Ku et al., 2003). However, there are studies showing that early approach (under 3 months) is a favorable prognostic factor regarding the treatment's efficiency (Goldfischer and Gerber, 1997).

Prevention, early diagnosis, and correct management of iatrogenic ureteral lesions are of paramount importance in reducing morbidity after pelvic and abdominal surgical interventions.

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Chapter 13

Abstract

Ureteroscopy in children, in pregnancy, and in patients with reno-ureteral malformations present certain particular aspects regarding the diagnostic algorithm, operative technique, and postoperative follow-up. The difficulties regarding retrograde endoscopic treatment in these cases derive from the particular anatomic aspects, as well as the characteristics that limit the use of some types of common instruments during ureteroscopy in the "index patient," as defined by the EAU/AUA Consensus.

Keywords

diagnostic ureteroscopy
extracorporeal lithotripsy
pediatric ureteroscopy
Ho:YAG laser
endopyelotomy
ultrasonography
ureteral endoprosthesis
percutaneous nephrostomy
reno-ureteral abnormalities

13.1. Generalities

Ureteroscopy in children, in pregnancy, and in patients with reno-ureteral malformations present certain particular aspects regarding the diagnostic algorithm, operative technique, and postoperative follow-up.

The difficulties regarding retrograde endoscopic treatment in these cases derive from the particular anatomic aspects, as well as the characteristics that limit the use of some types of common instruments during ureteroscopy in the “index patient,” as defined by the EAU/AUA Consensus (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

Thus, classic rigid and semirigid endoscopes are inadequate for ureteroscopy in children, pregnancy, or patients with malformations, due to their design and dimensions adapted to the upper urinary tract of the standard adult. At the same time, the physiological characteristics of pregnant women limit the use of fluoroscopy during the procedure.

Due to these technical problems, a significant number of patients were ineligible for minimally invasive treatment. Solving this problem required the search for viable solutions.

The development of miniaturized semirigid and flexible ureteroscopes, as well as of modern energy sources, has allowed the broadening of the indications of retrograde endoscopy to now include these categories of patients.

Although the retrograde ureteroscopy technique in these situations is similar to the standard one, there are some particularities that must be known and applied in order to achieve optimal results with minimal

13.2. Ureteroscopy in children

Although the first retrograde ureteroscopic evaluation was performed by Hugh Hampton Young in 1929 on a 2-month-old child with bilateral hydronephrosis secondary to posterior urethral valves (Young and McKay, 1929), the introduction of the retrograde approach of the upper urinary tract in pediatric patients was the result of a long evolution of endoscopic instruments and technique. Only in 1998 did the results published by Ritchey and Shepard mark a new era in the use of ureteroscopy in children (Ritchey et al., 1988; Shepherd et al., 1988).

Currently, retrograde ureteroscopy is considered a safe technique for the diagnosis and treatment of upper urinary tract conditions in children. The main indications are represented by Reddy (2004):

- the diagnosis of high origin hematuria or filling defects
- upper urinary tract lithiasis
- upper urinary tract obstruction (ureteral or ureteropelvic junction stenosis, caliceal diverticula, etc.)

13.2.1. Diagnostic Ureteroscopy

Diagnostic ureteroscopy is a technique performed more and more frequently in pediatric patients. The most frequent indication for diagnostic ureteroscopy is represented by essential benign hematuria, its incidence being of 1.3/1000 children (Daneshmand and Huffman, 2002). In contrast to adults, most lesions detected in children are benign (glomerular, interstitial, vascular, or urothelial). The treatment of these lesions is more often pharmacological and conservative, rather than surgical (Patel and Bissler, 2001). The ureteroscopic examination technique in these situations is similar to adult diagnostic ureteroscopy.

13.2.2. Upper Urinary Tract Lithiasis

13.2.2.1. Indications

Currently, the minimally invasive therapeutic methods have replaced open surgery in the treatment of upper urinary tract lithiasis in children. However, the debate continues regarding the efficacy and safety of the different options.

The progress and miniaturization of semirigid and flexible ureteroscopes that allow for the use of a large variety of accessory instruments has made possible their use in children.

The therapeutic attitude for ureteral lithiasis in pediatric patients requires an individualized approach, according to the particularities of each case. It was classically considered that the possibility of spontaneous elimination of the stone is greater in children than in adults. However, recent studies suggest that in pediatric patients, for stones measuring more than 3 mm, there is a relatively low chance of passing the uretero-vesical junction.

In contrast to adults, in whom the data from the literature has demonstrated that the rate of spontaneous elimination depends on the location and dimensions of the stones, there is scarce information regarding the correlations between these parameters and the spontaneous passage of the stone in children.

Absolute indications for interventional treatment are similar to those for adults, including infection, symptoms refractory to treatment, and secondary renal function impairment. The presence of associated congenital malformations must be considered in the evaluation of these patients. In children, both SWL and retrograde ureteroscopy require general anesthesia, so from this point of view there is no difference in favor of one of the procedures.

The localization of the ureteral stone does not decisively influence the choice of treatment. Ureteroscopic approach can be considered the first therapeutic alternative for distal ureteral lithiasis in children. Proximal ureteral stones can also benefit, in good conditions, from endoscopic treatment (Wollin et al., 1999).

In case of kidney stones, extracorporeal lithotripsy is the least invasive therapeutic alternative, with a stone-free rate of over 80% and minimal complications (Tan et al., 2004). The method's limitations derive from the relatively high rate of repeated procedures and the need for auxiliary maneuvers.

The desire to completely extract the stones after a single procedure is an argument in favor of the ureteroscopic approach in the detriment of SWL.

The therapeutic decision also depends on the particular anatomic aspects that may be encountered in children. With the invention of flexible ureteroscopes with the possibility of obtaining an efficient deflection, even in the presence of accessory instruments inserted into the working channel, the indications for retrograde approach have broadened, including even pyelocaliceal stones.

The EAU/AUA Consensus considers SWL and retrograde ureteroscopy to be first-line methods for the treatment of upper urinary tract lithiasis in pediatric patients, the choice of one alternative or the other depending on the size and anatomic particularities of the child (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

13.2.2.2. Particularities of the Instruments

Modern equipment allows for the safe ureteroscopic approach in children over 3 months old (Schuster et al., 2002).

The use of adequate instruments is essential for the success of the procedures. The differences between the instruments used in children and the classic ones are minimal and generally consist of their reduced length and size.

Thus, the distal end of the semirigid ureteroscopes used in pediatric patients has a diameter of 4.7 F, which increases progressively toward the proximal end. The semirigid instruments are ideal for the approach of the ureter up to the iliac vessels, with the advantages of having two channels (one for irrigation and a working channel), superior durability, and easier maintenance.

Interventions on the proximal ureter or pyelocaliceal system can be performed under optimal conditions using flexible ureteroscopes, due to the possibilities conferred by the primary and secondary deflections. The secondary, passive deflection is rarely necessary during flexible ureteroscopy in children, the complete inspection of the pyelocaliceal system, including the lower caliceal group, being possible using a single deflection. Regarding the methods for intracorporeal lithotripsy, electrohydraulic fragmentation has proved to be effective, but is encumbered by the risk of ureteral wall lesions. The use of the Ho:YAG laser is a viable alternative, presenting the advantage of reduced aggressiveness and of obtaining fragments small enough to be eliminated spontaneously, without requiring additional active extraction maneuvers (Reddy et al., 1999; Wollin et al., 1999).

13.2.2.3. Technical Particularities

Performing the ureteroscopic approach under optimal conditions in children requires an adequate preoperative assessment. This should include knowledge of any previous urological conditions or interventions, with direct implications on the choice of surgical technique.

Regarding the irrigation fluid, the use of water should be avoided because of the risk of circulatory absorption during the procedure, which may lead to severe intravascular hemolysis and hyponatremia. Therefore, it is preferred to use saline solution, heated to 37°C in order to prevent hypothermia that may occur during prolonged interventions. Electrosurgical procedures require the use of sorbitol, glycine, or sterile water.

Preoperative antibiotic prophylaxy is recommended in all cases.

The ureteroscopic approach in children is performed under general anesthesia. It should also be taken into consideration that urethral stimulation due to instrumentation can precipitate laryngospasm (Reddy, 2004).

Children under 1 year old can be positioned for flexible ureteroscopy in the supine position with legs spread, without the need of flexing them on mounts. Older patients may be positioned in the classic lithotomy position, avoiding excessive abduction of the limbs and compression on the nerve trunks. Positioning can be difficult in children with conditions such as paraplegia or spastic tetraplegia, spina bifida, etc., which can cause muscle contractures, osteopenia, or ankylosis. In these cases, an alternative that should be considered is the antegrade approach (Reddy, 2004).

In boys it is mandatory to examine and dilate, when necessary, the urethral meatus. Cystoscopy is performed in the same manner as for adults, and before beginning the actual procedure it is recommended to drain the bladder in order to prevent the effects of hyperpressure.

The ureteral orifice is then catheterized with a 0.035 in. guidewire. If the diameter of the intramural ureter is large enough, the ureteroscope can be ascended on the guidewire under direct visual control. The persistence of congenital ureteral folds in children may represent an element of difficulty, without being a contraindication for the ureteroscopic approach. The particularities with regard to the diameter and dimensions of the ureter in pediatric patients compared to adults, described by Cussen (1971), require an adaptation of the surgical technique. In children, the average diameter of the ureter ranges between 2 mm and 5 mm. The morphological particularities depend on the patient's age and size. Four areas of physiological narrowing of the ureteral lumen have been described in children: the ureteral orifice, the intramural ureter, the crossing with the iliac vessels, and the ureteropelvic junction.

Ureteroscopic access to the upper urinary tract can be facilitated by using two guidewires: one for safety and one ascended through the endoscope's working channel. In case of difficulties passing the ureteral orifice, the flexible ureteroscope can be rotated, helping to overcome the narrowed area of the lumen. If these maneuvers are ineffective, dilatation of the ureteral orifice is recommended.

The use of the balloon catheter (Fig. 13.1) is an effective and safe maneuver, but dilation is usually greater than that required for ureteroscopic approach (Fig. 13.2) (Shepherd et al., 1988).

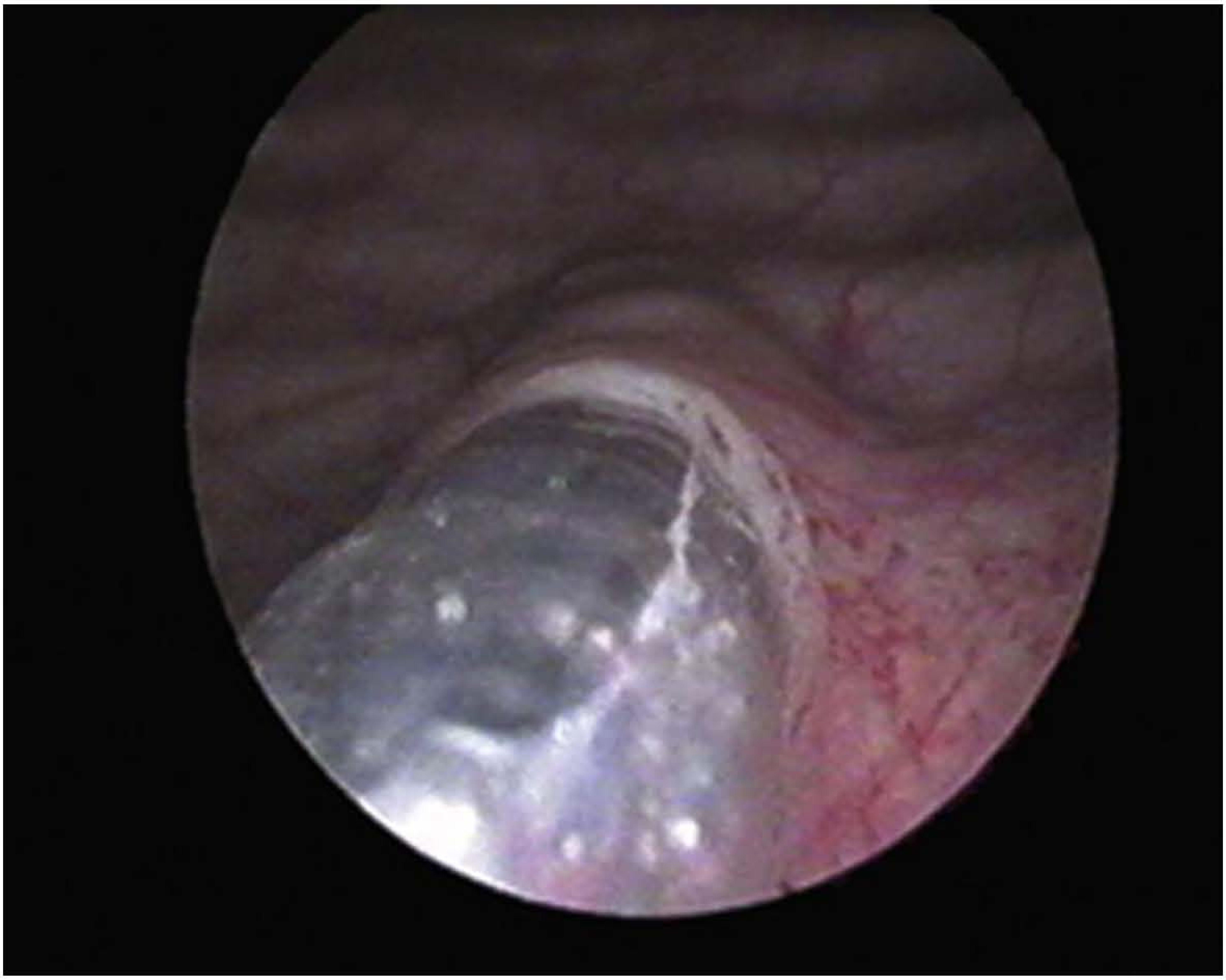


Figure 13.1 **Balloon dilation of the ureteral orifice.**

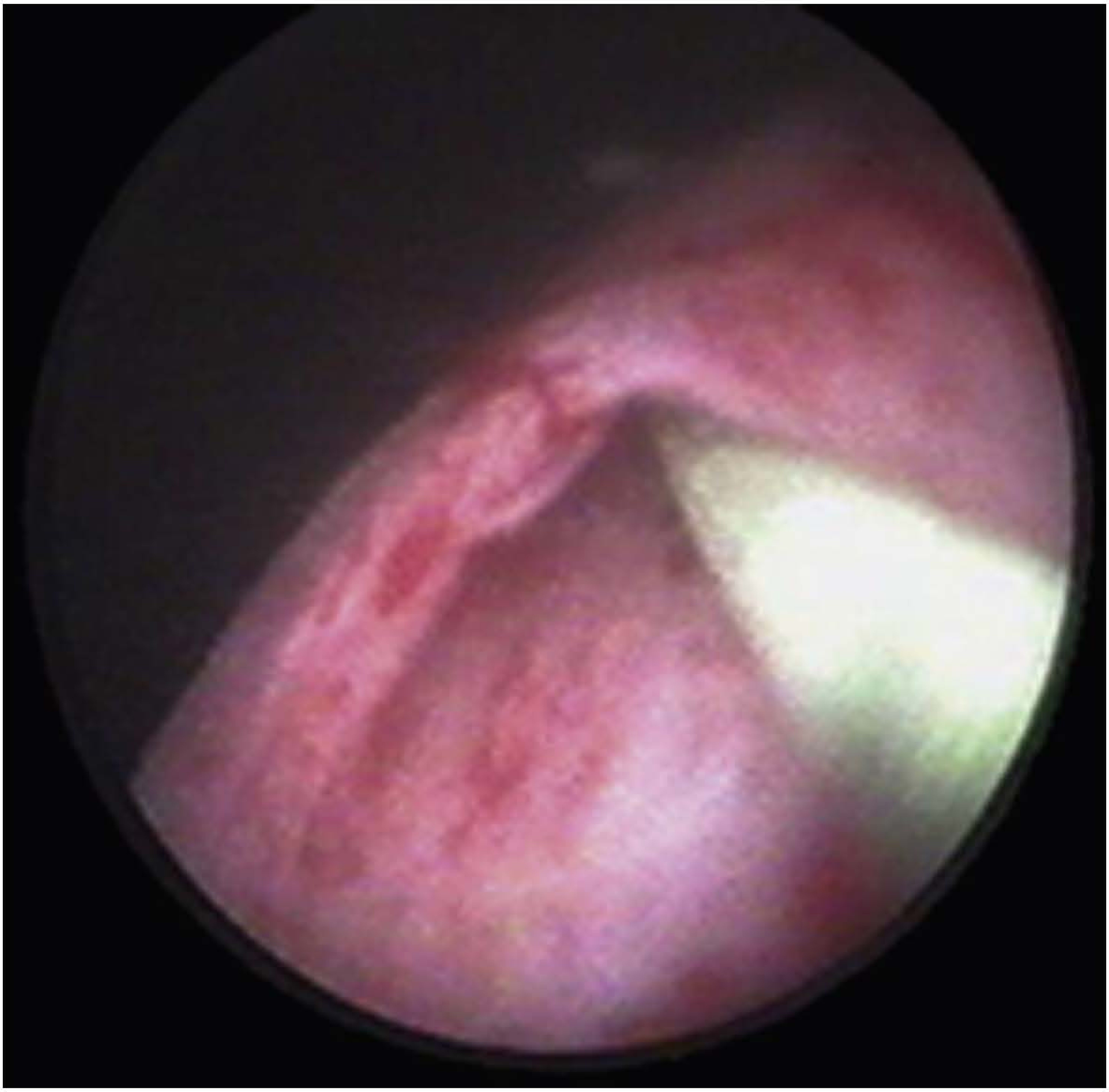


Figure 13.2 **Aspect of the ureteral orifice after dilation.**

When dilation is required, this may also be carried out using a sheath with a progressive external diameter from 6 F to 10 F. This type of active dilation is best performed on a more rigid guidewire.

Active dilation is necessary in approximately 30% of the cases in which ureteroscopy is performed in children, and age is not a predictive factor regarding the indication for this maneuver (Minevich et al., 2005).

If the active dilation methods are ineffective, passive dilation with a JJ catheter is recommended.

This alternative can be used in prepubertal children in order to reduce the risk of injuring the intramural ureter and of vesicoureteral reflux. It is recommended to use 3.7–4.8 F ureteral autostatic catheters, which are maintained for 3–14 days. Prophylactic antibiotic treatment is recommended as long as the catheter is maintained.

When therapeutic maneuvers are to be performed, it is recommended to maintain a safety guidewire. The use of hydrophilic safety guidewires is contraindicated because of the risk of accidental or spontaneous extraction.

The approach of the upper urinary tract can also be achieved using a ureteral access sheath with a diameter between 10 F and 14 F, this usually requiring pre-procedural stenting.

For calculi located in the distal and middle ureter, the ureteroscopic approach can be achieved using semirigid mini-ureteroscopes (Fig. 13.3). Stones located in the proximal ureter may be approached in the same manner, but sometimes it is necessary to use flexible ureteroscopes. Pyelocaliceal stones require flexible ureteroscopic approach.

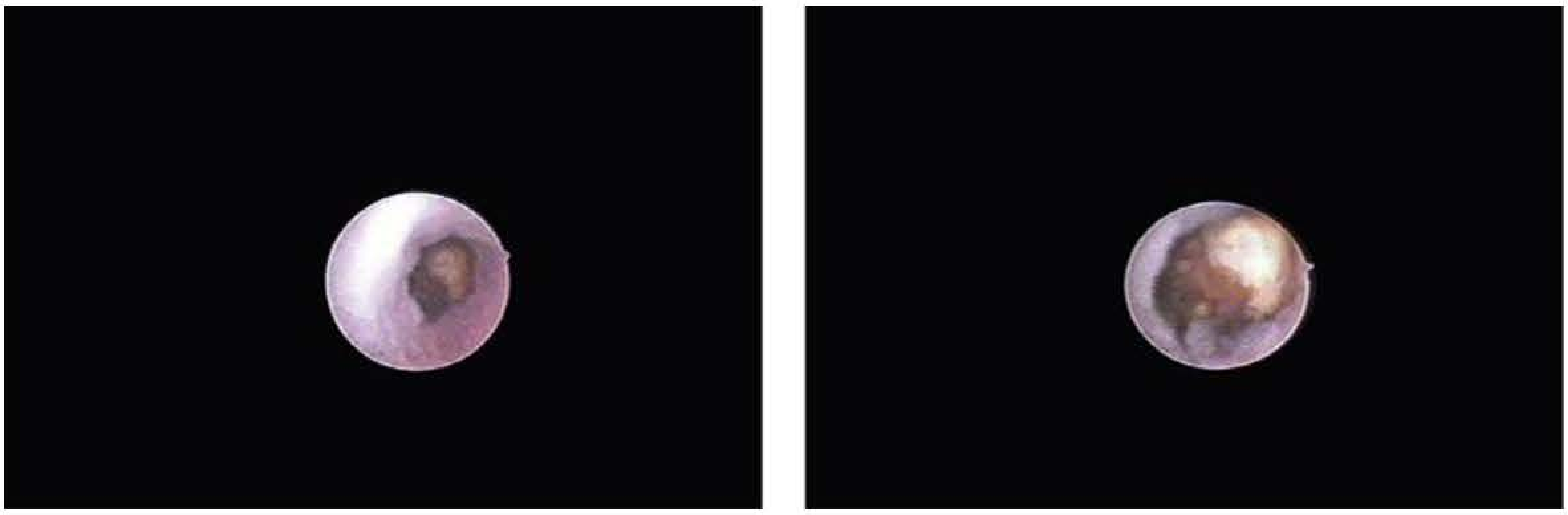


Figure 13.3 **Retrograde ureteroscopic approach for ureteral lithiasis in a child using a semirigid mini-ureteroscope.**

Small stones can be extracted with various accessory instruments (forceps, basket catheters, etc.), while large stones require lithotripsy, in situ or after mobilization into the suprajacent ureteral segment. Currently, the Ho:YAG laser is considered by most authors the preferred method of lithotripsy.

The indications for postoperative ureteral stenting are similar to ureteroscopy in adults, being represented especially by the cases that require laborious interventions with ureteral orifice dilation, with lesions or edema of the ureteral wall, or after incisions of the urinary tract.

Due to the fact that maintaining an eventual wire attached to the distal end of the stent cannot be taken into consideration in pediatric patients (because of the risk of accidental extraction), the removal of the autostatic catheter requires a second general anesthesia (Reddy, 2004).

Retrograde ureteroscopic procedures in children who have a history of bladder neck reconstruction requires the use of small diameter endoscopes to avoid iatrogenic lesions of this area.

In patients with ureterocystoneostomy, the approach of the terminal ureter depends on the type of reimplantation. Additional difficulties may arise in cases with crossed reimplantations, in which access to the terminal ureter is hindered by the position and intramural tract. In these situations, catheterization of the neo-orifice with a guidewire with an angled end or with a distal end with active deflection is recommended. After gaining access, the guidewire can be replaced, on the catheter, with a rigid guidewire that facilitates ureteroscopic access. In the case of a very difficult access, the use of an antegrade approach will also be assessed.

13.2.2.4. Results

According to various studies, the stone-free rate after ureteroscopic treatment was approximately 89%, depending especially on the location of the stones (Wollin et al., 1999).

Schuster reported a 7-year experience in the treatment of ureteral calculi in children, studying a group of 25 cases. The stone-free rate was 92% after one procedure and 100% after two procedures. No intraoperative complications were described (Schuster et al., 2002).

There are still debates regarding the risk of vesicoureteral reflux after aggressive dilation of the upper urinary tract's distal segment (Garvin and Clayman, 1991). Studies in which post-ureteroscopic mictional cystographies were performed demonstrated that dilation of the ureteral orifice to over 12 F did not determine a significant reflux (Shepherd et al., 1988; Thomas et al., 1993).

13.2.3. Upper Urinary Tract Stenosis

Open surgical pyeloplasty was long considered the treatment of choice in adult ureteropelvic junction stenosis, with a success rate of over 95%. Lately, technical evolution has brought into the spotlight the endoscopic and laparoscopic methods of treatment, with a low associated morbidity and comparable success rates. Expanding the indications to include children was a natural consequence, but the results obtained up to now are not sufficient to determine with certainty the place of these methods in the therapeutic armamentarium of pediatric urology.

Starting from this premise, choosing the therapeutic option for ureteropelvic junction stenosis in children must take into consideration numerous aspects: the success rates of endopyelotomy compared to the other methods, the risks involved including bleeding, the need for open surgery in case of procedure failure, or the possibility of progressive renal function impairment.

From a technical point of view, endopyelotomy in children is carried out in a manner similar to interventions in adults.

The incision should be performed in a posterolateral position until the peripyelic and periureteral fat are visualized. Cold-blade knife, electrocautery, or laser can be used. Ureteral endoprosthesis with a 6–8 F/12–14 F pyelostent for 4–6 weeks is recommended at the end of the intervention.

As in the case of endopyelotomy performed in adults, the success rate depends on a number of factors. Thus, a reduction of the relative kidney function below 25%, severe hydronephrosis, or the presence of polar vessels are negative prognostic factors, representing contraindications of retrograde endopyelotomy (Lam et al., 2003).

Gerber and Bogaert reported favorable results of the method in children over 4 years old with primary or secondary ureteropelvic junction stenosis without polar vessels. However, due to the small number of patients (three and eight cases respectively), the published data must be validated by other studies (Bogaert et al., 1996; Gerber et al., 2000).

Evaluating the results of retrograde endopyelotomy after the failure of pyeloplasty, Braga reported a modest success rate of only 39% (Braga et al., 2007).

Ureteral stenosis is relatively rare in children, in most cases their occurrence being secondary to endoscopic manipulation of the upper urinary tract. Retrograde endoureterotomy is recommended especially for distal ureteral stenosis, while stenosis of the proximal or middle ureter benefits from antegrade endoureterotomy as the first therapeutic alternative.

Retrograde endoureterotomy technique follows the same principles as in adults, the placement of a stent with the highest caliber tolerated by the patient (usually 4.5–7 F) being recommended (Reddy, 2004).

13.3. Ureteroscopy in pregnancy

Retrograde ureteroscopic approach in pregnant women is a method that has relatively recently entered current practice, as a natural consequence of technological advances regarding endoscopes and accessory instruments. The main indication is represented by lithiasic obstruction of the upper urinary tract.

Urinary lithiasis in pregnant women has a particular practical importance because of both the maternal and the fetal risks. Renal colic, infection, and obstruction can be associated with premature birth (Hendricks et al., 1991).

The incidence of ureteral lithiasis in pregnant women varies between 1:1500 and 1:2500 (Rodriguez and Klein, 1988), similar to that in the general population (Hendricks et al., 1991). The factors favoring lithogenesis (hypercalciuria and hyperuricuria) (Gertner et al., 1986; Swanson et al., 1995) are counterbalanced by the inhibiting factors (increased citraturia and magnesuria). Hypercalciuria is due to vitamin D3 synthesized in the placenta, which induces the suppression of PTH secretion (Gertner et al., 1986).

Ureteral lithiasis in pregnant women presents certain diagnostic and especially therapeutic particularities. Renal colic is the most common nonobstetrical cause of abdominal pain. The associated gastrointestinal symptoms can be due to pregnancy, so in these situations fever, persistent bacteriuria or microscopic hematuria are elements that can guide the diagnosis.

In order to avoid the hazards of radiation, ultrasonography represents the first-line imagistic exploration for urinary lithiasis in pregnancy. The physiological dilation of the upper urinary tract, especially of the right kidney, can cause false-positive results. Moreover, this assessment is dependent on the operator, and there are conflicting data regarding its efficacy. Stothers and Lee showed a sensitivity of 34% and a specificity of 86% for this method (Stothers and Lee, 1992), while Parulkar et al. (1998) observed a sensitivity of 95.2% and a specificity of 87%. If the ultrasonographic assessment is inconclusive, radiological evaluation may be required. The overlap of the fetal skeleton can compromise radiological detection of the calculi. Swartz and Reichling emphasized that the first trimester of pregnancy is the period with the highest risk of fetal malformations or of miscarriage after exposure to radiation (Swartz and Reichling, 1978). They estimated that a dose of 25–80 rad doubles the teratogenic risk. However, exposure to radiation for one film is less than 20 mrad, representing less than 1% of the critical dose. Fluoroscopic control during endoscopic interventions is contraindicated in pregnant women.

According to the EAU/AUA Consensus, when the information provided by ultrasonography is not sufficient, a radiological examination consisting of a simple reno-vesical radiography and two urographic clichés at 15 and 60 min after the administration of contrast agent can be performed. CT scanning is not indicated in this category of patients, and magnetic resonance imaging can identify the obstruction site, as well as the stone that is observed as a filling defect (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

Pregnancy remains an absolute contraindication for SWL due to the teratogenic effect of shockwaves and of X-rays (when detection is possible only by fluoroscopy) on fetal development (Streem, 1997).

Because of these clinical issues, the treatment of reno-ureteral lithiasis in pregnant women has particular options. The goal of treatment is to maintain the functionality of the kidney, to remit the symptoms, and to prevent urinary infection. Thus, a conservative treatment will be applied whenever possible, most calculi being eliminated spontaneously during pregnancy or immediately after birth. In approximately 66–85% of cases, spontaneous elimination of calculi can occur after hydration, analgesics, and in case of associated urinary infection, after antibiotic treatment (Jones et al.,-1979; Stothers and Lee, 1992). The stage of pregnancy will be taken into account when choosing analgesics and antibiotics, in order to avoid causing fetal toxicity.

Endourological treatment has the same indications as in the general population, but it must be applied earlier because of the risk of premature birth induced by the renal colic. The recommended endourological therapeutic options can be ureteral endoprosthesis, percutaneous nephrostomy, and retrograde ureteroscopy (Geavlete et al., 2006).

The safest and least aggressive method is ureteral endoprosthesis, the stone being removed after birth (Loughlin and Bailey, 1986; Jarrard et al., 1993). However, some studies have shown an increased risk of stent encrustation, probably due to hypercalciuria, requiring their replacement every 6–8 weeks (Kavoussi et al., 1992). Therefore, ureteral endoprosthesis is the preferable alternative in the second and third trimester of pregnancy, while percutaneous nephrostomy is preferred in the first trimester.

Classically, the ureteroscopic treatment of ureteral lithiasis in pregnant women was considered a high-risk procedure (Rittenberg and Bagley, 1988). Lately, more and more urologists prefer the removal of ureteral stones by retrograde ureteroscopy under spinal anesthesia or sedoanalgesia, which has proven to be an effective and well-tolerated procedure. Reports in the literature have confirmed the efficiency and low rate of complications of this alternative (Scarpa, 1996; Shokeir and Mutabagani, 1998). Although the use of rigid or semirigid ureteroscopes has determined favorable results, flexible instruments (Fig. 13.4) provide superior maneuverability and reduce the risk of complications.

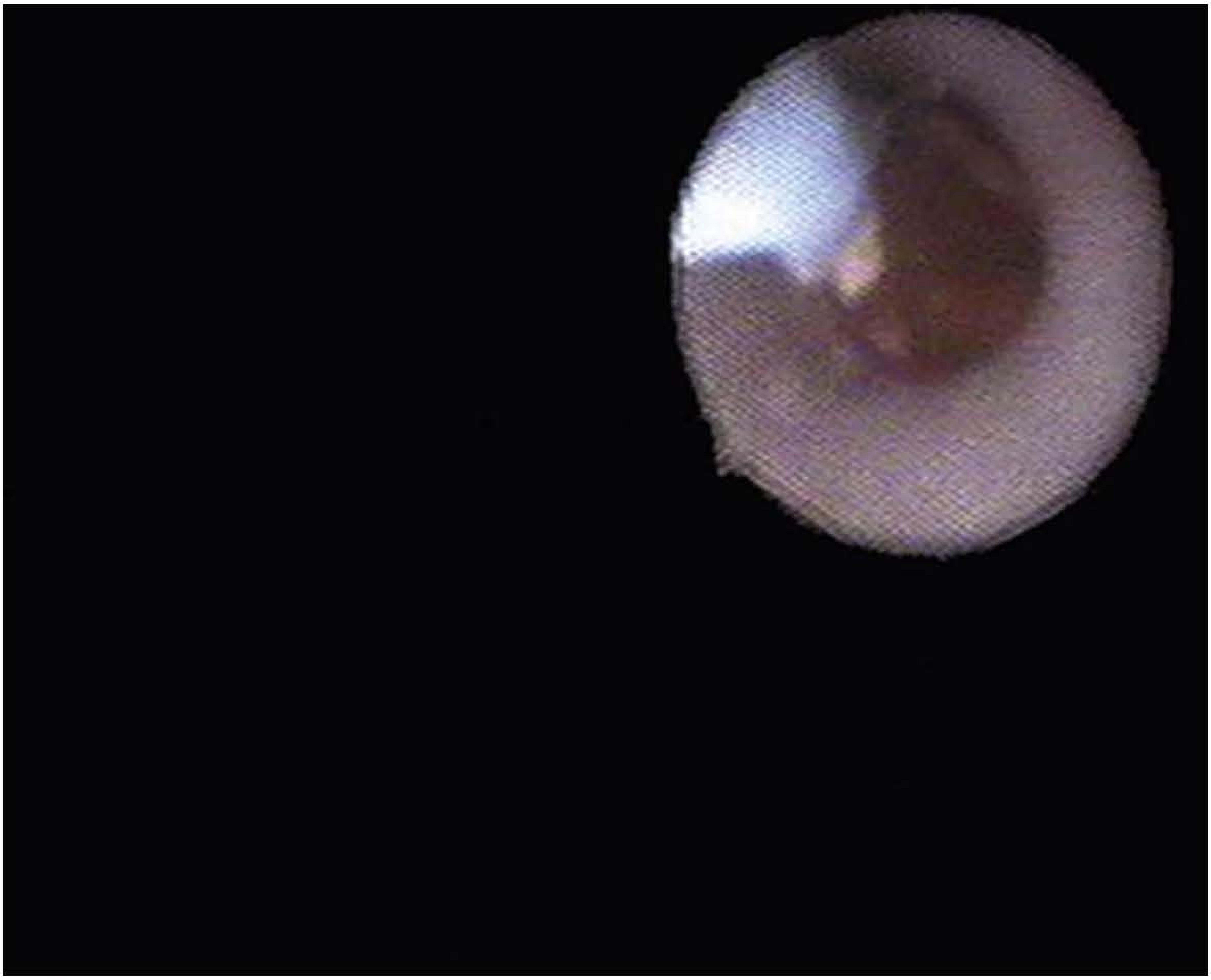


Figure 13.4 **Extraction of a ureteral stone with a tripod grasper in a pregnant woman (flexible ureteroscopy).**

Fragmentation of calculi can be performed safely using laser or pneumatic lithotripters (Ulvik et al., 1995; Scarpa, 1996; Gorton and Whitfield, 1997; Shokeir and Mutabagani, 1998).

The EAU/AUA Consensus recommends the use of Ho:YAG laser lithotripsy, which, due to its low penetrability, is associated with a minimal risk of fetus aggression (EAU/AUA Nephrolithiasis Guideline Panel, 2007).

Consequently, Kavoussi et al. (1998) argued that, in selected cases, ureteroscopic treatment is preferred to ureteral stenting.

13.4. Ureteroscopy in patients with reno-ureteral abnormalities

Reno-ureteral morphological abnormalities can be congenital (this category including a wide range of malformations of the kidney or upper urinary tract) or acquired (uro-cutaneous or uro-enteric derivations, etc.).

Retrograde ureteroscopic approach can be difficult in many of these cases, requiring adaptation of the endoscopic equipment and technique to their specific particularities.

Congenital malformations are secondary to anomalies occurring during embryonic development.

Ureteral malformations can be classified into abnormalities regarding the following:

- number
- position, insertion at the pyelic level or opening into the bladder
- structure
- caliber

In turn, the kidney may present abnormalities regarding the following:

- number
- position
- rotation
- volume and structure
- shape and fusion
- vascularization
- pyelocaliceal system

Excepting the renal malformations related to volume and structure, all the other reno-ureteral abnormalities can generate problems regarding the retrograde ureteroscopic access. Moreover, these malformations create conditions that favor a number of pathological changes in the upper urinary tract in general, and especially reno-ureteral stones (Fig. 13.5). Morphological abnormalities also induce some particularities in the evolution of these cases, requiring an individualization of the indications for active treatment.

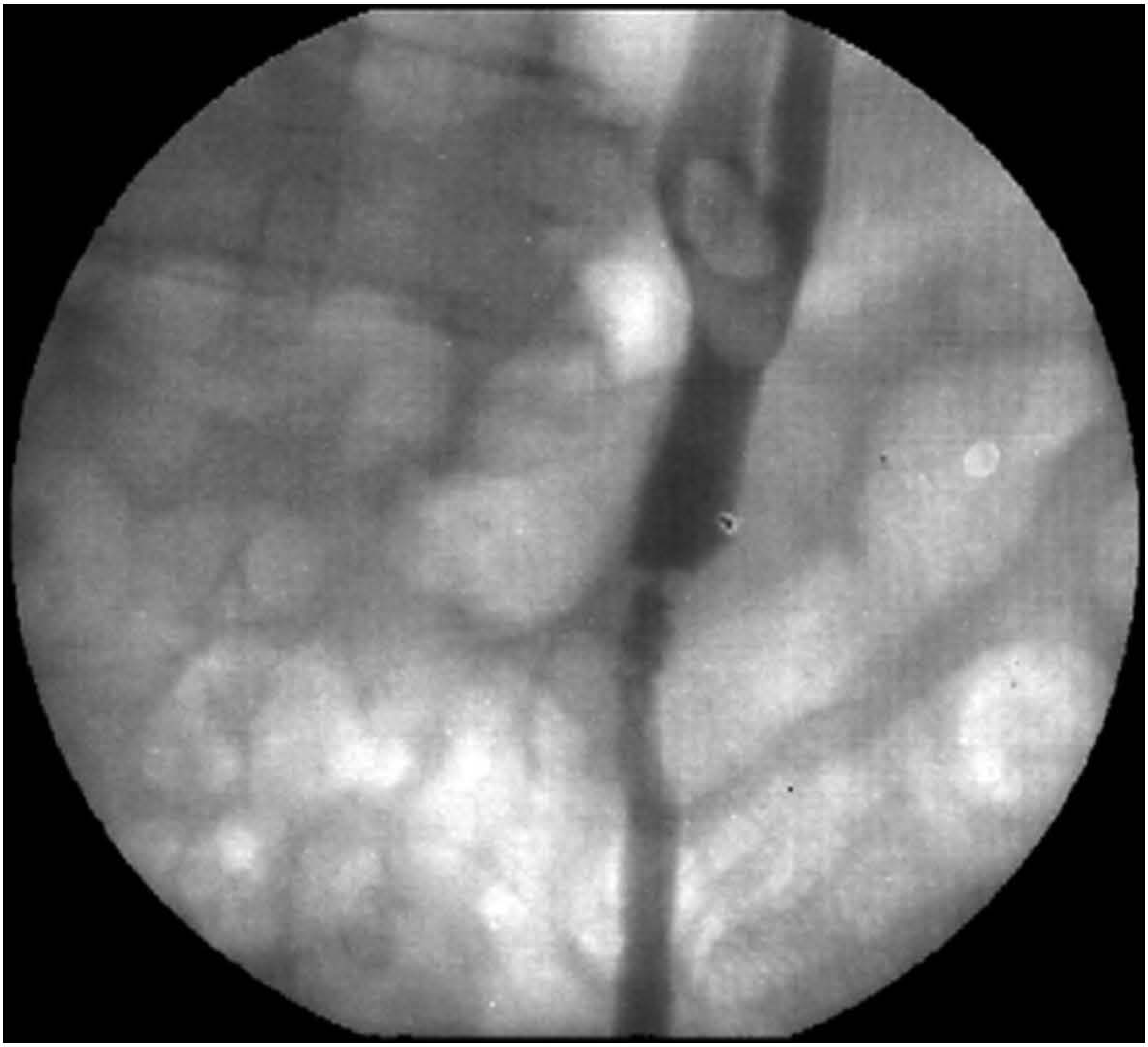


Figure 13.5 **Incomplete pyelo-ureteral duplicity with stones in one of the pyelons.**

Ureteral duplicity is the most common abnormality of the ureter. It can be classified into incomplete pyelo-ureteral duplicity (ureter fissus) and complete pyelo-ureteral duplicity (ureter duplex) (Fig. 13.6).

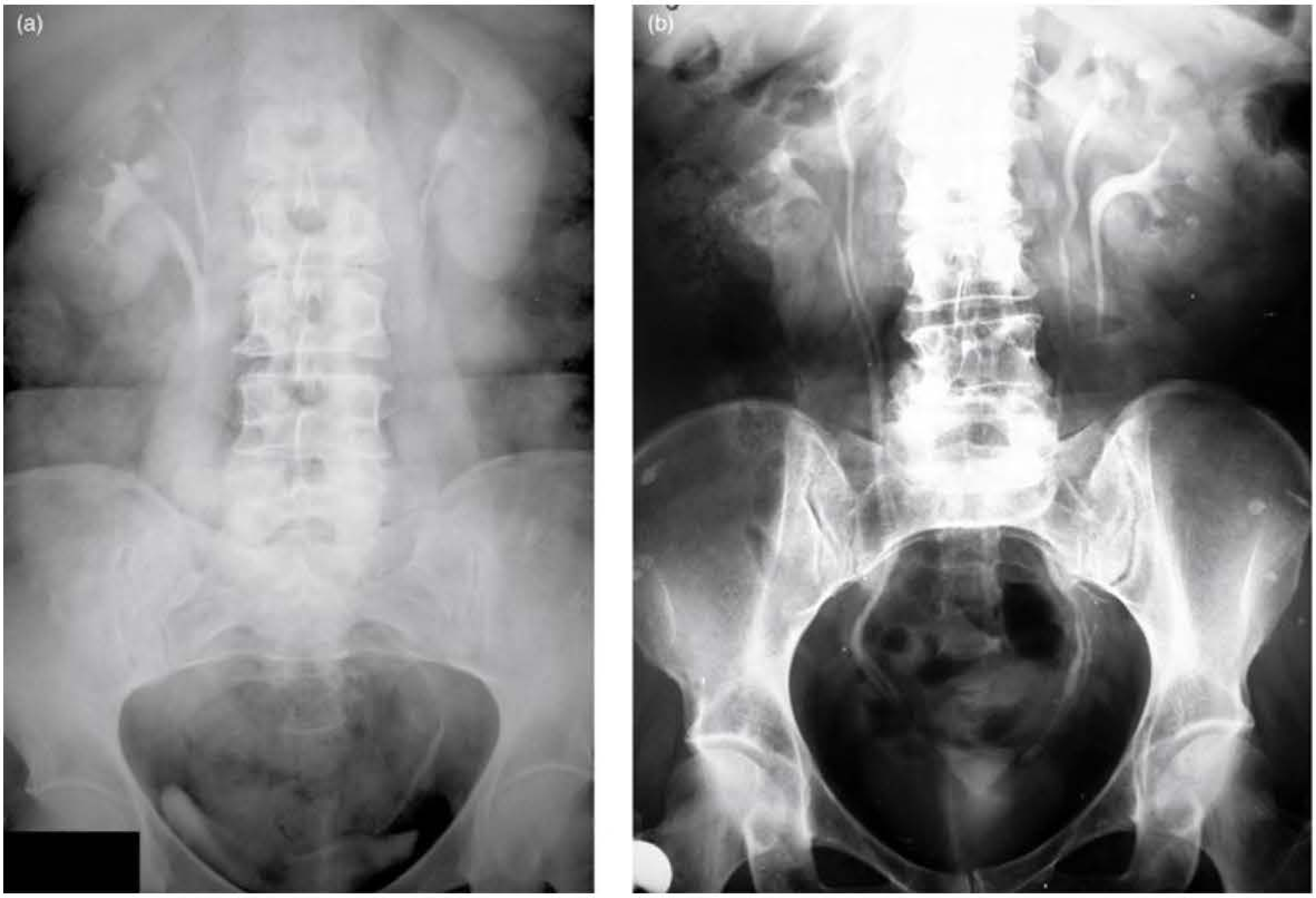
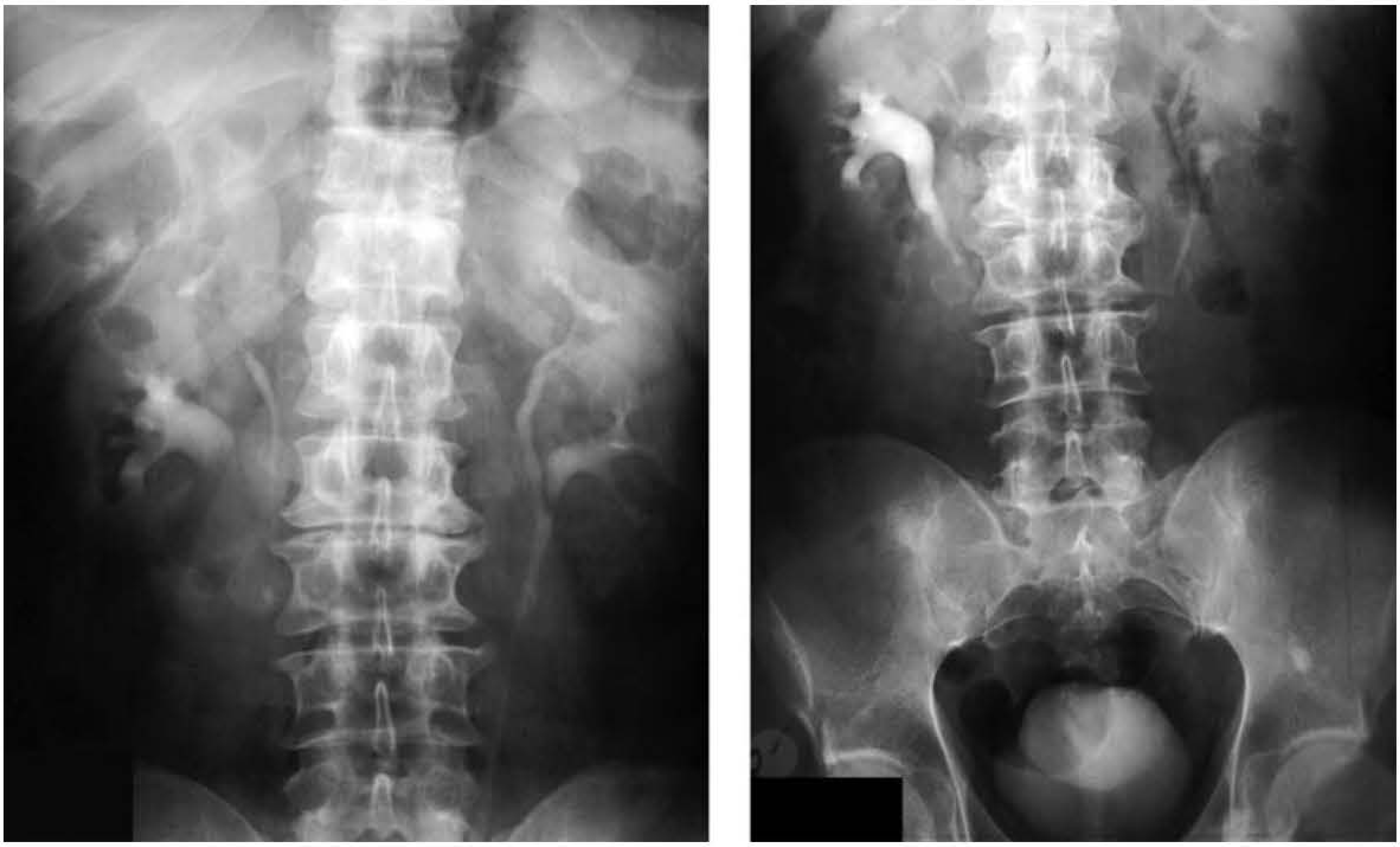


Figure 13.6 **Radiological aspects of incomplete right pyelo-ureteral duplicity (a) or complete bilateral pyelo-ureteral duplicity (b).**

Retrograde ureteroscopic treatment in patients with complete pyelo-ureteral duplicity presents no notable particularities, and each pyelon can be approached similarly to the normal upper urinary tract. In these cases, Weigert and Meyer's law should be taken into account in identifying the ureteral orifice to be approached: the lower pyelon's orifice occupies the cranial and lateral position, while the upper pyelon's orifice has a caudal and medial position.

Incomplete pyelo-ureteral duplicity may raise difficulties in the retrograde approach of the associated condition (lithiasis, stenoses, etc.) (Fig. 13.7). These difficulties are usually related to the problems associated with passing the area where the two systems converge.



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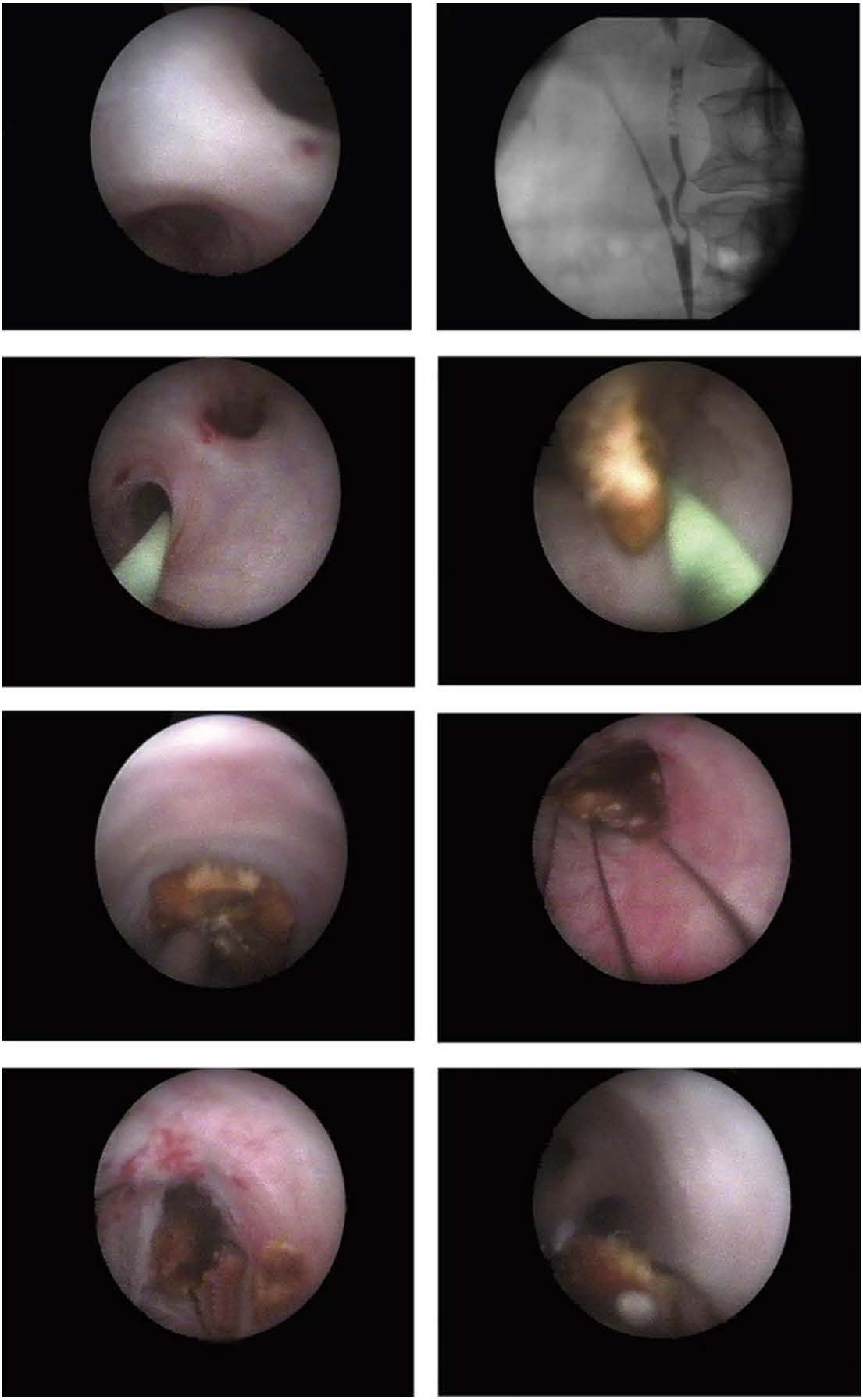
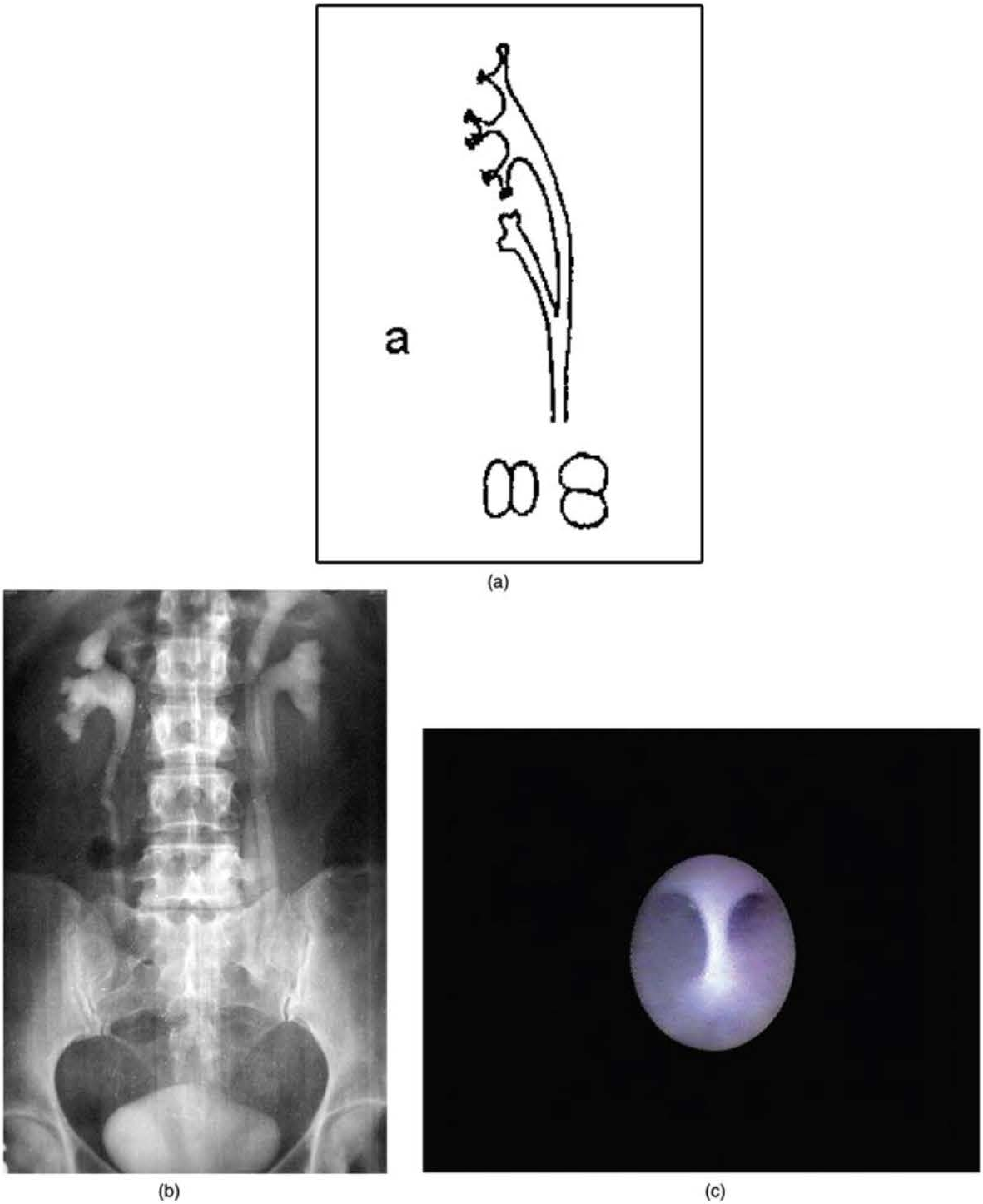


Figure 13.7 **Retrograde ureteroscopic approach of a stone in the lower pyelon of an incomplete pyelo-ureteral duplicity.**

Geavlete et al. (2001) described a classification of this malformation, with direct implications on the therapeutic particularities regarding the obstruction of the junction between the two ureters.

Thus, retrograde ureteroscopic exploration describes four morphological types of the junction between the two systems:

- Type I – “shotgun barrel” wide junction (Fig. 13.8)
- Type II – lateral insertion of one of the ureters (Fig. 13.9)
- Type III – punctiform insertion of one of the ureters (Fig. 13.10)
- Type IV – valvular aspect of the insertion of one of the ureters (Fig. 13.11)

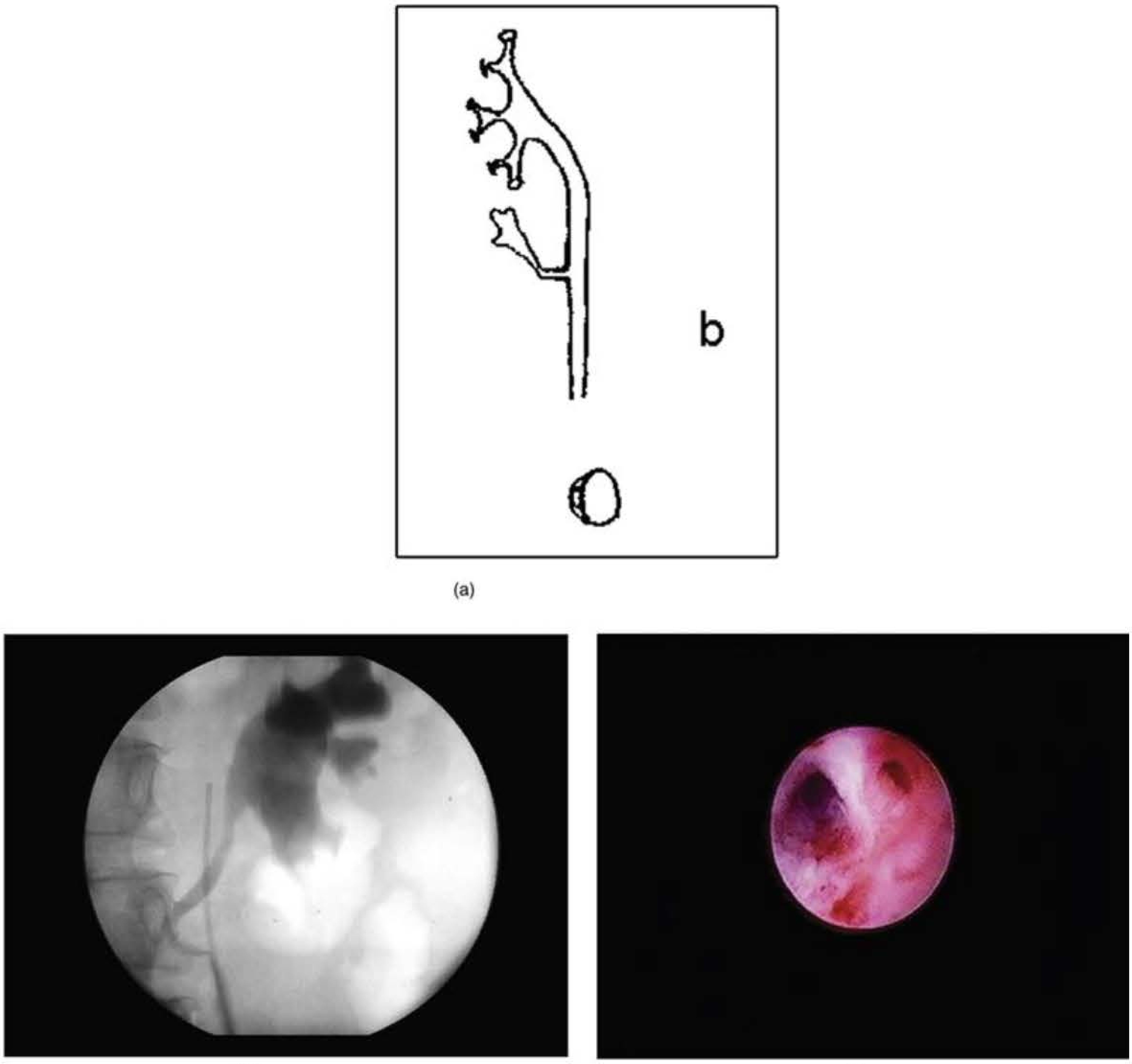


(a)

(b)

(c)

Figure 13.8 **Type I incomplete pyelo-ureteral duplicity: shotgun barrel.** Diagram (a), radiological (b) and endoscopic (c) aspects.



(a)

(b)

(c)

Figure 13.9 **Type II incomplete pyelo-ureteral duplicity: lateral insertion.** Diagram (a), radiological (b) and endoscopic (c) aspects.

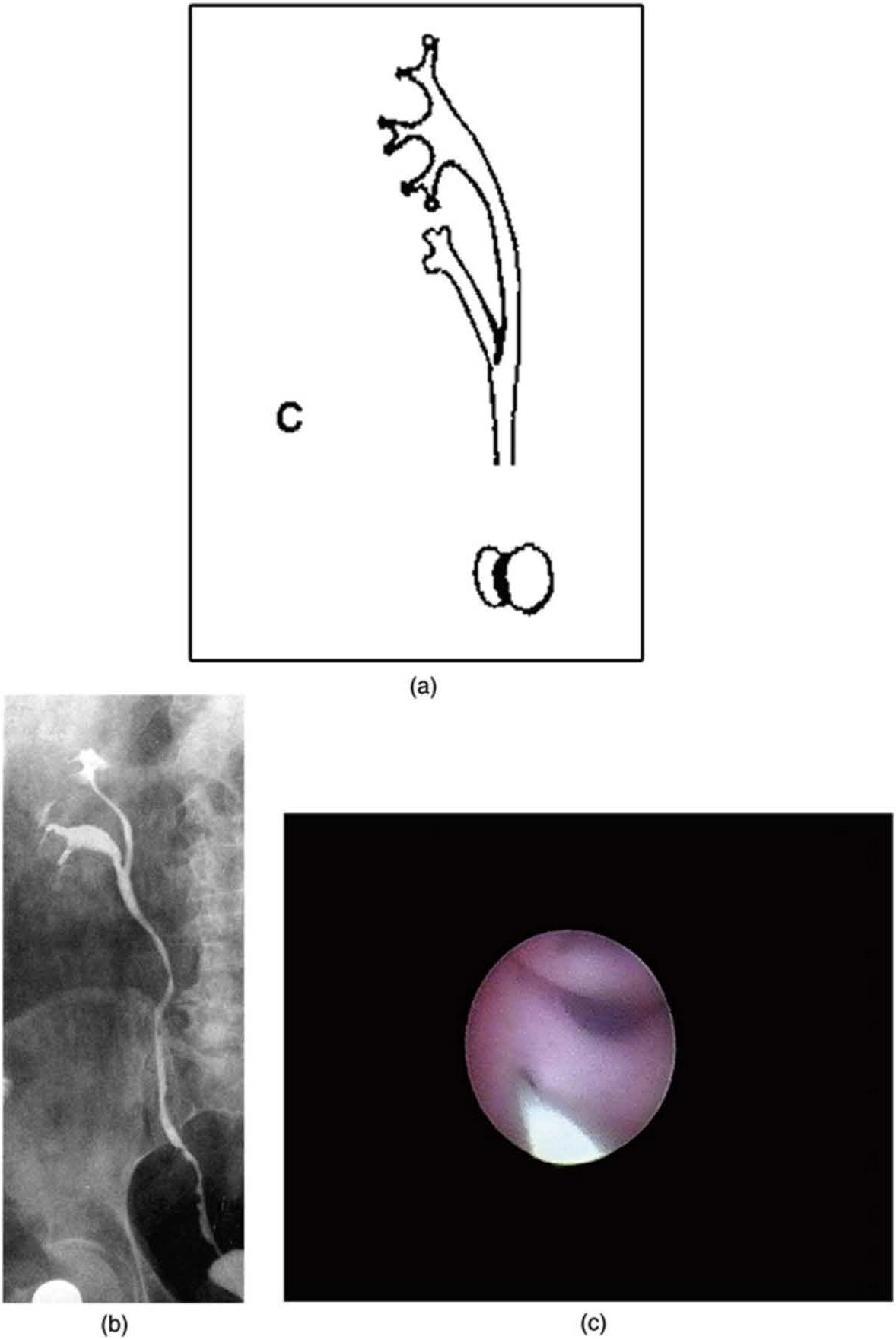


Figure 13.10 **Type III incomplete pyelo-ureteral duplicity: punctiform stenosis.** Diagram (a), radiological (b) and endoscopic (c) aspects.

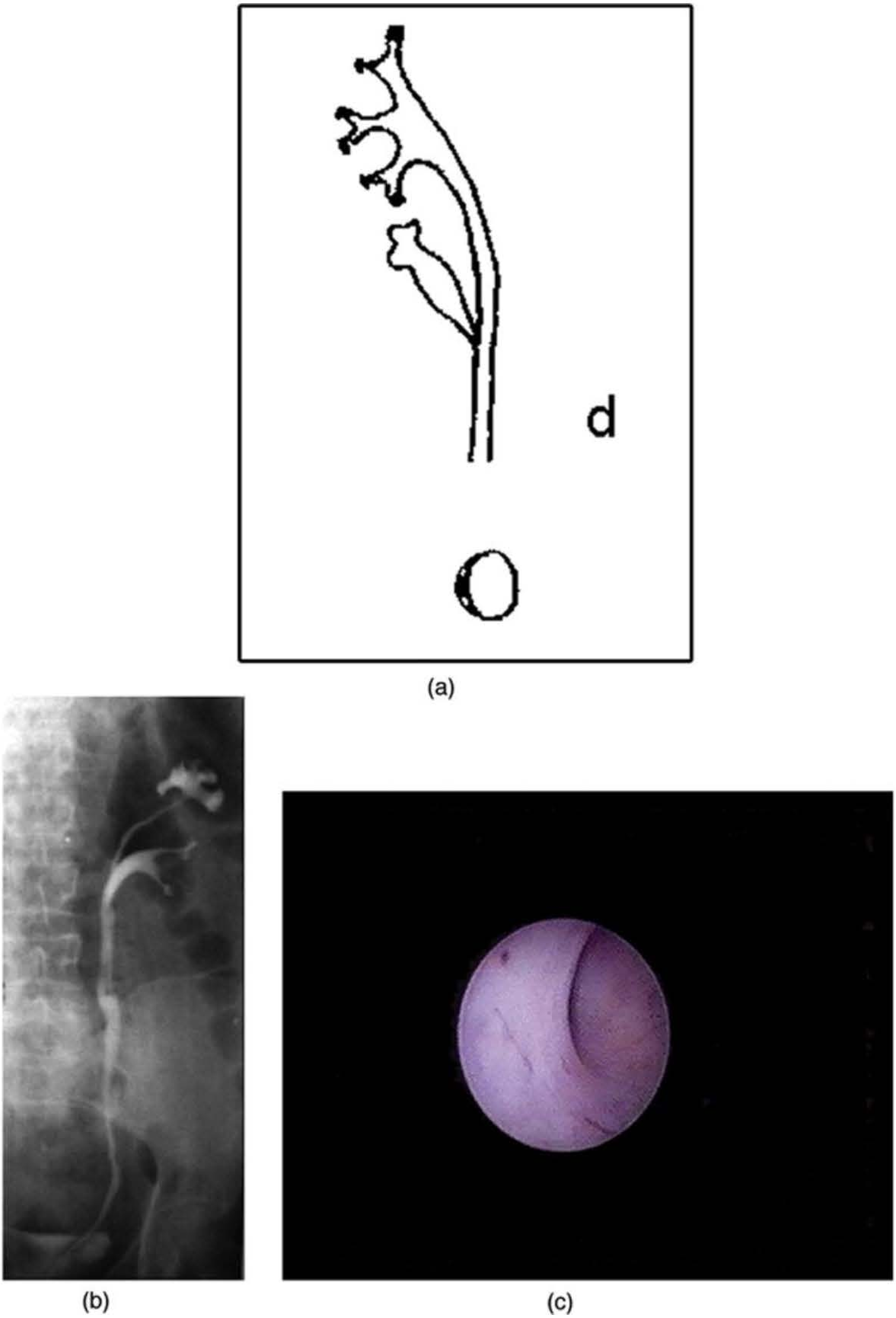


Figure 13.11 **Type IV incomplete pyelo-ureteral duplicity: valvular aspect.** Diagram (a), radiological (b) and endoscopic (c) aspects.

Functional obstruction is generally associated with the “shotgun barrel” aspect of the junction, while the areas of organic ureteral stenosis appear in the other three aspects (Fig. 13.12).

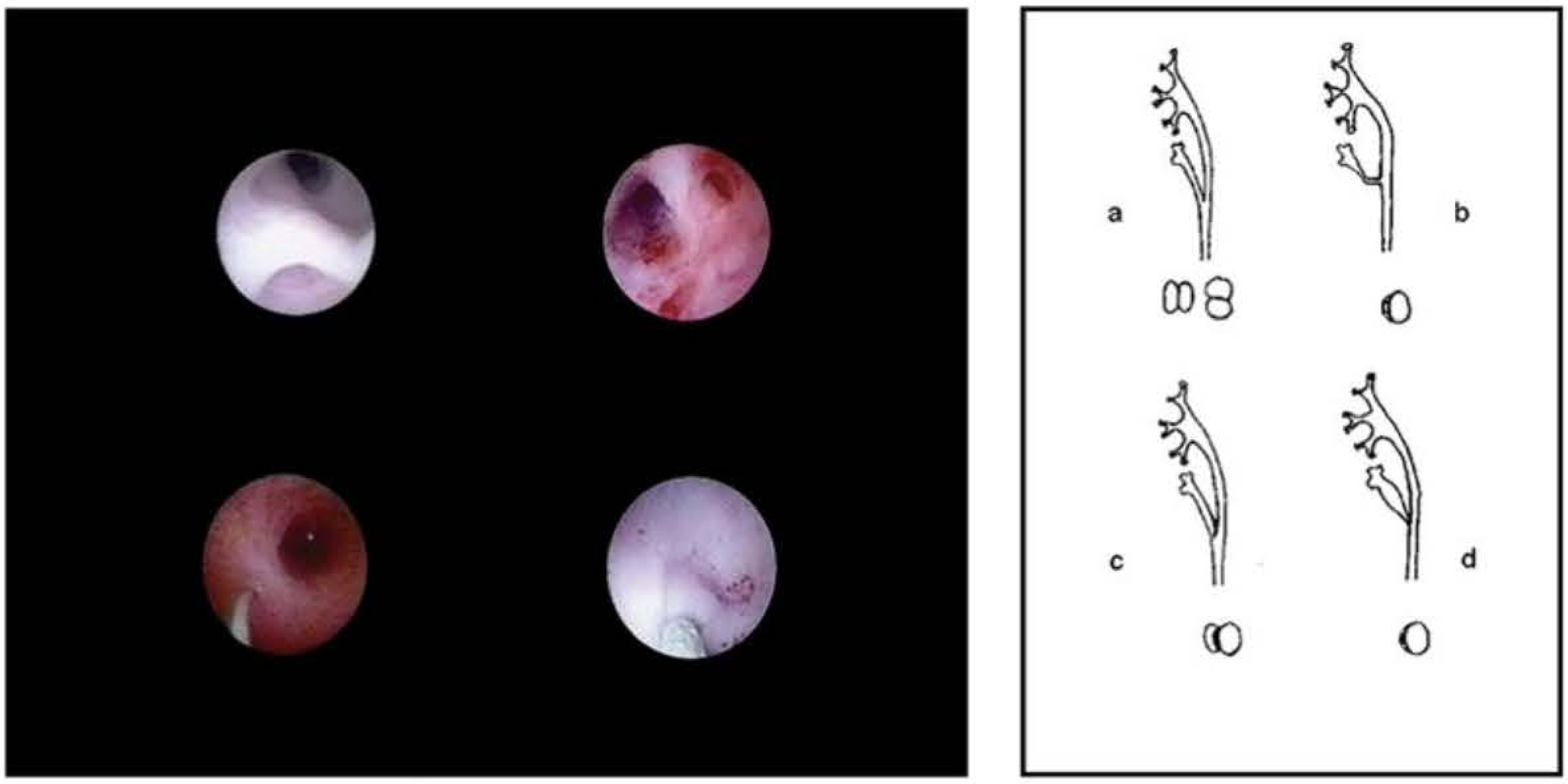


Figure 13.12 **Comparative aspect of the four types of incomplete pyelo-ureteral duplicity.**

Stenosis of the area of implantation of a pyelon at the level of the other may require endoscopic incision (Fig. 13.13).

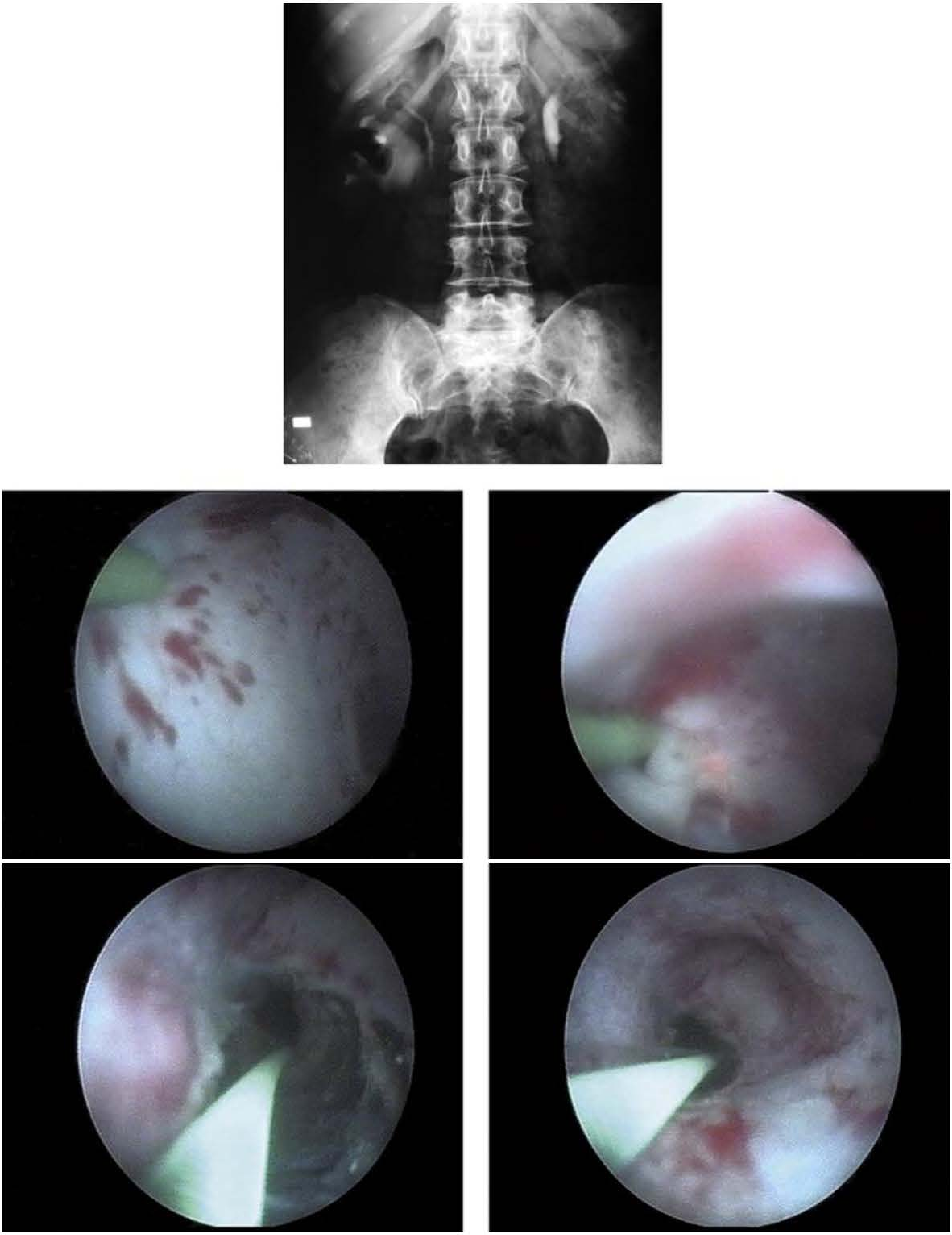


Figure 13.13 **Laser incision of the stenotic punctiform opening of the lower pyelon in a patient with incomplete right pyelo-ureteral duplicity.**

By using flexible ureteroscopes, these junction areas can be visualized in good condition and all pyelons can be explored directly in order to determine the type of obstruction and any associated conditions.

Megaureter may be associated with lithiasis, its retrograde ureteroscopic treatment posing a number of difficulties related to the wide space in which lithotripsy has to be performed (Fig. 13.14).

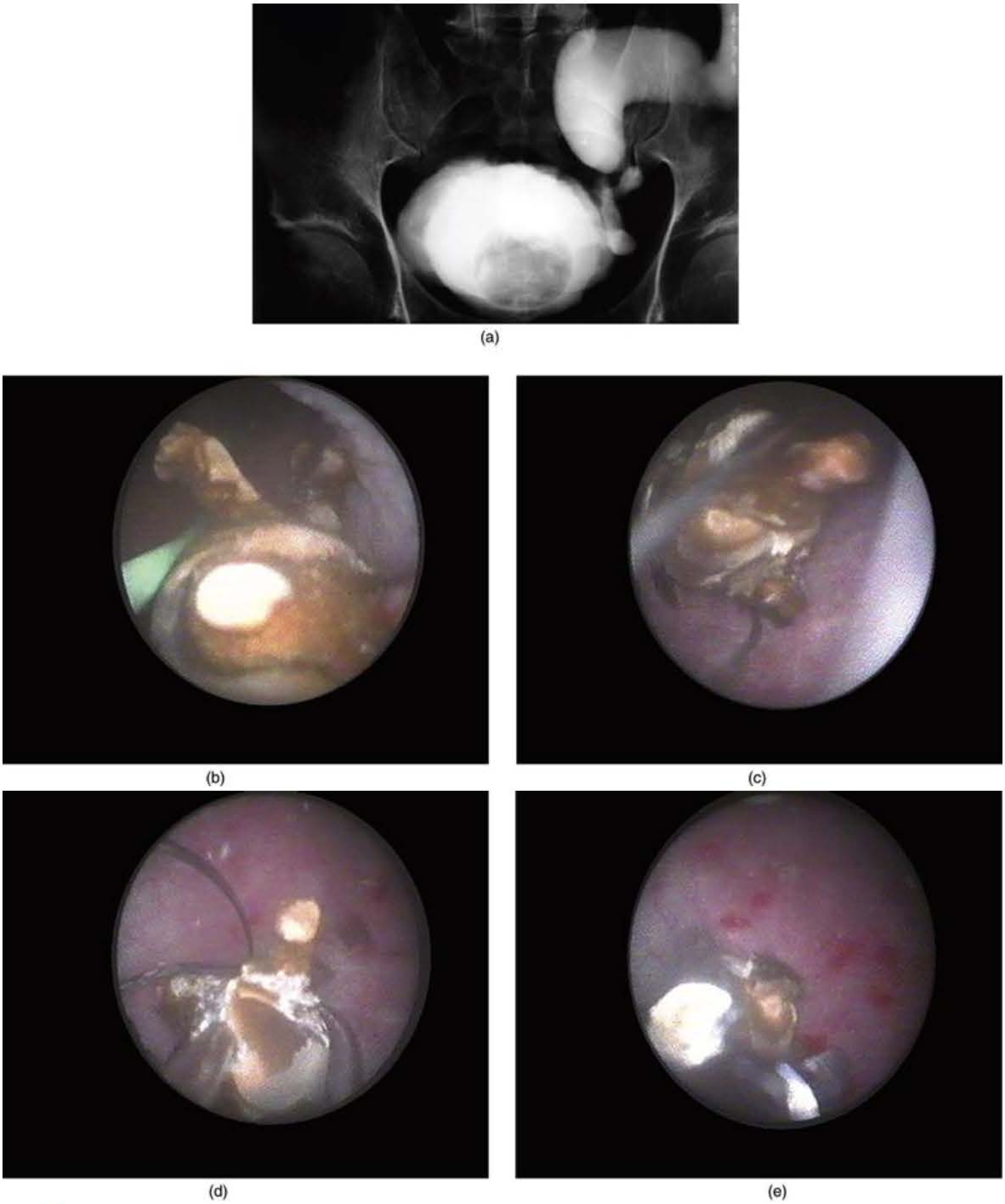


Figure 13.14 **Retrograde ureteroscopic treatment of a stone in megaureter (a, b), with ballistic lithotripsy between the spirals of the basket catheter (c, d) and extraction of the fragments with a forceps (e).**

The retrograde treatment of lithiasis associated with ureterocele must be preceded by endoscopic incision of the malformation. This maneuver is required due to the difficult approach of the upper urinary tract and the need to prevent recurrence by removing the obstructive cause.

The endourological treatment of the malformed kidney pathology – especially ectopic ones (Fig. 13.15) or with abnormalities related to shape and fusion/horseshoe kidney – is limited in options compared to the index patient. Thus, percutaneous surgery may be contraindicated due to the difficult and risky access, while SWL is associated with low success rates due to the relations with the bony pelvis and to the impediments in evacuating the lithiasic fragments, etc.

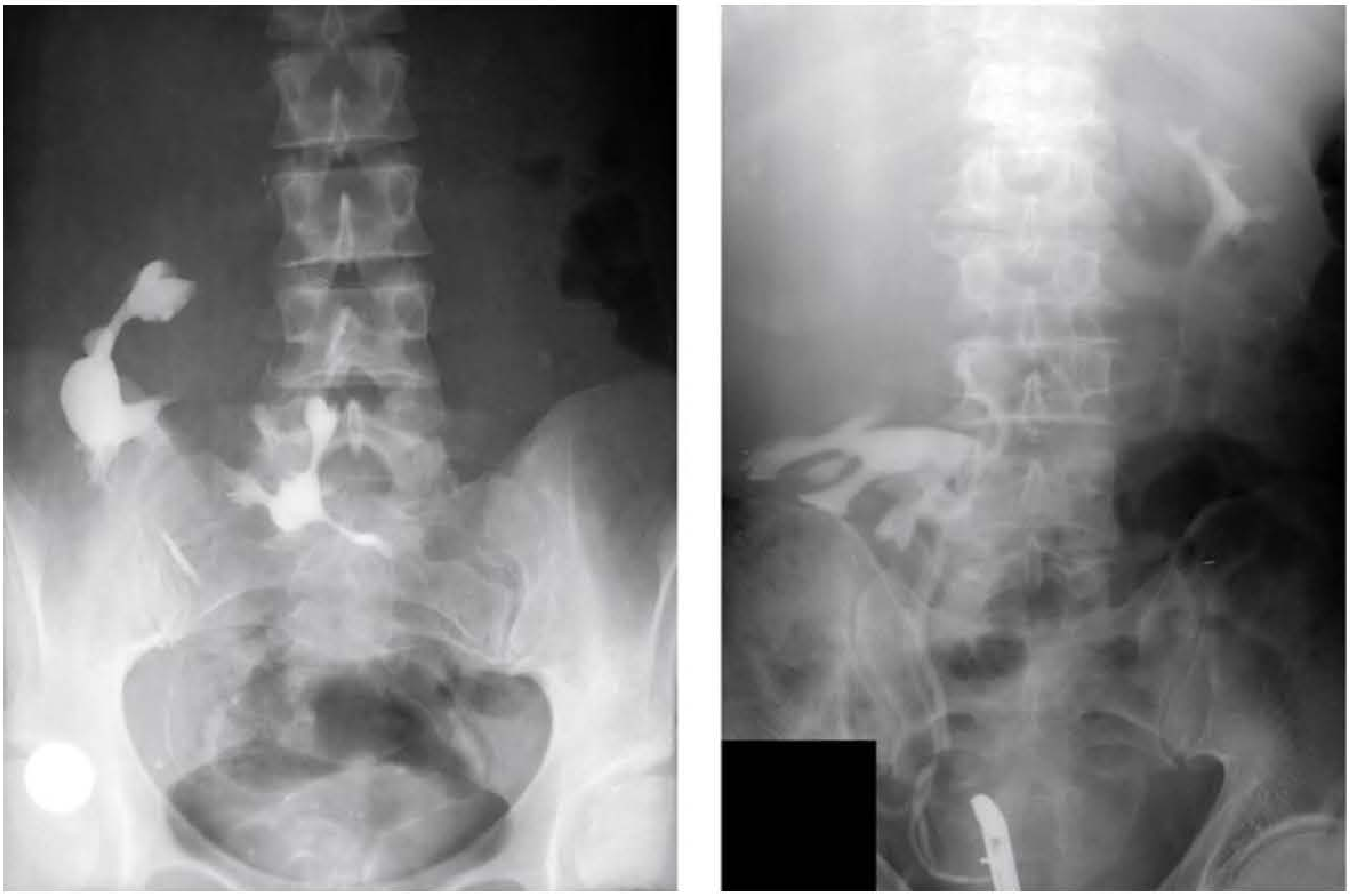


Figure 13.15 **Radiological aspects of renal ectopia associated with rotation abnormalities.**

The development of flexible ureteroscopes and of lithotripsy sources efficient even for bulky lithiasic masses (Ho:YAG laser) have provided the solution to these problems. By diversifying the indications for retrograde approach in these patients, the place within the therapeutic armamentarium that the other minimally invasive methods could not take has been occupied.

The retrograde exploration of the ureter and of the pyelocaliceal system in patients with urinary derivations requires, almost exclusively, the use of flexible ureteroscopes. The procedure follows the principles described in the previous chapters, but some access difficulties may occur.

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